

**EXAMINING THE IMPACT OF A LITERACY-INFUSED, INQUIRY-BASED SCIENCE  
CURRICULUM ON ENGLISH LEARNERS LIVING ON THE TEXAS-MEXICO  
BORDER**

A Dissertation

by

LILEANA RÍOS-LEDEZMA

Submitted to the Office of Graduate and Professional Studies of  
Texas A&M University  
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

Chair of Committee,  
Committee Members,

Rafael Lara-Alecio  
Hector Rivera  
Beverly J. Irby  
Fuhui Tong

Head of Department,

Shana Hagan-Burke

December 2019

Major Subject: Educational Psychology

Copyright 2019 Lileana Ríos-Ledezma

## **ABSTRACT**

The purpose of this mixed methods study was to examine the impact of a literacy-infused, inquiry-based science curriculum on English learners' (ELs') English oral language expressive skills as measured by the Woodcock Muñoz Survey-Revised subtests: Picture Vocabulary and Verbal Analogies (Woodcock-Muñoz-Sandoval, Ruef, & Alvarado, 2005). In addition to their oral language expressive skills, this study also sought to examine if there existed differences between male and female ELs' oral language expressive skills. Moreover, a quantitative analysis was utilized to further examine differences in the utilization of "student-talk" and/or "student-teacher interactions" which may have occurred between classrooms where the intervention was used and where the intervention was not used.

The present study was derived from a randomized, longitudinal, field-based NSF funded research project (PR/Award Number U411B120047) English Language and Literacy Acquisition-Validation (ELLA-V)) which sought to target ELs and the development of their second language in a large, urban school district on the Texas-Mexico border. This study used archived data from one of two interventions: Content Reading Integrating Science for English Language and Literacy Acquisition (CRISELLA). The data provided was of third grade students and their pre- and post-tests from two oral language proficiency tests. Utilizing descriptive statistics, a two-way analysis of covariance (ANCOVA) as well as a Chi-Square Analysis of Homogeneity, a sample of 141 participants was analyzed to answer the research questions.

As indicated by the statistical analysis, the data demonstrated that there was a statistically significant difference between the treatment and control groups. English learners who participated in the intervention showed higher means in the area of oral language skills as

reflected by the Muñoz Survey-Revised subtests. The two-way ANCOVA analysis also did not find a statistically significant difference between males and females indicating that the intervention did not discriminate among gender groups. Furthermore, the Chi-Square Analysis of Homogeneity indicated that there were differences that existed in the time allocated for the variety of activity structures between treatment and control classrooms in which ELs had opportunities to engage in “student-talk” and/or “teacher-to-student interactions”.

This is crucial to note because the intervention followed in the treatment classrooms provided for such opportunities for these activity structures to generate “student-talk” and/or “student-teacher interactions”. Additionally, the study presents much needed research in the areas of ELs, literacy, STEM and gender in a high-needs area: the Texas-Mexico border.

## **DEDICATION**

To my God, family, and friends who always believed in me.

## ACKNOWLEDGEMENTS

My sincerest appreciation to my committee chair, Dr. Rafael Lara-Alecio and committee members, Dr. Beverly Irby, Dr. Fuhui Tong, and Dr. Hector Rivera for your time and efforts in guiding me through this delicate process and important part of my life in my educational career. Special thanks to Dr. Rafael Lara-Alecio and Dr. Fuhui Tong for allowing me access to Project ELLA data and an opportunity to make a contribution to the world of Bilingual Education.

I would also like to express gratitude to Dr. David Jimenez, who through his friendship provided the opportunity for me to grow as a graduate student, bilingual educator, and researcher. Thank you for mentoring me and believing in me! Dr. Shifang Tang, thank you for spending quality time with me in order to understand and complete the necessary statistical procedures involved in this present study. You are truly appreciated!

To Dr. Alcione Ostorga, I would like to extend a special, heartfelt “thank you”! You were that special professor in my life who took me under your wing and helped me pave the way for this great accomplishment. I will be forever grateful that you chose me to partner with you on the authorship journey. Thank you for choosing me all those years ago.

To my husband, Daniel and my beautiful baby girl, Aleyna Rose. Thank you for always supporting me in the special ways you know how. Your patience, love, and sacrifices during this time has not gone unnoticed. I love you more every day!

Of course, none of this would have been made possible had my entire family, my parents, Gabino & Stephanie Ríos, not always believed in me. There are too many to name, but know I thank God, every day for giving me such a supportive family!

To God be all the honor and glory!

## **NOMENCLATURE**

BICS	Basic Interpersonal Communicative Skills
CALP	Cognitive Academic Language Proficiency Skills
ELLA-V	English Language and Literacy Acquisition - Validation
ERIC	Education Resources Information Center
ESL	English as a Second Language
ELL	English Language Learner
EL	English Learner
L1	First Language
L2	Second Language
LPAC	Language Proficiency Assessment Committee
NCLB	No Child Left Behind Act
STAAR	State of Texas Assessments of Academic Readiness
STEM	Science Technology Engineering and Math
TBOP	Transitional Bilingual Observation Protocol
TEA	Texas Education Agency
TEKS	Texas Essential Knowledge and Skills

## TABLE OF CONTENTS

	Page
ABSTRACT.....	ii
DEDICATION.....	iv
ACKNOWLEDGEMENTS.....	v
NOMENCLATURE.....	vi
TABLE OF CONTENTS.....	vii
LIST OF FIGURES.....	ix
LIST OF TABLES.....	x
CHAPTER I INTRODUCTION.....	1
Definition of Terms.....	5
Statement of the Problem.....	11
Theoretical Framework.....	13
Research Overview.....	22
Purpose of the Study.....	23
Research Questions.....	24
Significance of the Study.....	25
Limitations.....	25
Assumptions.....	26
Organization of the Study.....	26
CHAPTER II REVIEW OF LITERATURE.....	27
Eligibility Criteria.....	28
Search Process.....	29
Selection Process.....	34
Content Area Instruction.....	35
Literacy-Infused, Inquiry-Based Science Instruction.....	39
Gender Differences in the STEM Classroom.....	62
Student Discourse in Science Classrooms .....	66
Summary.....	70
CHAPTER III METHODOLOGY.....	72
Research Design and Sampling.....	72
Context of the Study.....	73
Program Intervention.....	74

Research Questions.....	79
Instrumentation.....	80
Data Collection.....	84
Data Analysis.....	85
Limitations.....	87
CHAPTER IV DATA ANALYSIS AND FINDINGS.....	88
Research Question One.....	89
Research Question Two.....	91
Research Question Three.....	92
Research Question Four.....	99
Summary.....	105
CHAPTER V DISCUSSION, LIMITATIONS, CONCLUSIONS AND RECOMMENDATIONS.....	107
Discussion.....	109
Limitations.....	114
Conclusions and Recommendations.....	115
REFERENCES.....	117



## LIST OF FIGURES

		Page
Figure 1	Conceptual Framework for Effective Instruction of ELs.....	14
Figure 2	PRISMA Flow Diagram of the Systematic Literature Review.....	34
Figure 3	Four-dimensional Transitional Bilingual Pedagogical Theory reprinted from (Lara-Alecio & Parker, 1994)).....	84

## LIST OF TABLES

	Page
Table 1    The 5-E Model.....	76
Table 2    Sample CRISELLA Scripted Lesson Plan Following 5-E Model.....	78
Table 3    Descriptive Statistics of Pre- and Post-test Scores on Picture Vocabulary Subtest by Condition.....	89
Table 4    Descriptive Statistics of Pre- ad Post-test Scores on Verbal Analogies Subtest by Condition.....	91
Table 5    Descriptive Statistics of Picture Vocabulary Pre-tests by Gender.....	92
Table 6    Descriptive Statistics of Picture Vocabulary Post-tests by Gender.....	93
Table 7    Descriptive Statistics of Verbal Analogies Pre-tests by Gender.....	94
Table 8    Descriptive Statistics of Verbal Analogies Post-tests by Gender.....	94
Table 9    Levene’s Test of Equality of Error Variances for Control and Treatment Groups for Picture Vocabulary and Verbal Analogies.....	95
Table 10   ANCOVA Results for Picture Vocabulary.....	96
Table 11   ANCOVA Results for Picture Vocabulary.....	97
Table 12   Number of 20-Second Observational Videos by Condition.....	99
Table 13   Crosstabulation of Activity Structures by Condition.....	100
Table 14   Chi-Square Values by Activity Structures and Student Language.....	102
Table 15   Crosstabulation of Student Language by Condition.....	103

## **CHAPTER I**

### **INTRODUCTION**

As the population makeup of the United States continues to shift and represent more culturally diverse individuals and speakers of a language other than English, educators throughout the nation are challenged to address the increasing academic achievement gaps between these individuals and their Anglo, native-English counterparts (Huerta & Spies, 2016). According to Pew Research Center (2017), immigrants in the United States account for 13.4% of the entire nations population; this is triple the 4.7% since 1970. Additionally, in 2015, 44% of immigrants in the United States reported Spanish as their native language (Pew Research Center, 2017). Overall, the number of Spanish speakers in the U.S. has grown rapidly in recent decades due to the arrival of new immigrants and increase in the nation's Hispanic population; thus, these identified English learners (ELs) and their academic achievement is critical to the continued future of the United States (Pew Research Center, 2015).

In Texas, the most recent data of English Language Learners (ELLs is a term used previously; however, used interchangeably with the new term, English Learners (ELs)), show that there were approximately 908,131 English Learners (Spanish speakers) in the 2017-2018 academic school year from early childhood education to third grade state-wide (Migration Policy Institute, 2018). Generally, as the grade level increases, the number of ELs decrease indicating that more students achieve English proficiency and exit EL status over time (Migration Policy Institute, 2018). Still, more than 80% of the ELs, approximately 680,000, are in grades Pre-kindergarten to fifth grade, or in elementary grades (Migration Policy Institute, 2018).

The No Child Left Behind Act (NCLB), passed by Congress in 2001 and signed into law by President George W. Bush in 2002, significantly increased the role of the federal government in holding schools accountable for measuring and reporting academic progress of all students (Klein, 2015). Particularly, the federal government sought to ensure the schools in the states heightened the performance of certain subgroups of students, such as English-language learners, special education students, low socio-economic-status children, whose achievement typically lags behind their mainstream peers (Klein, 2015). Under NCLB, states are required to test all students in the subjects of reading and math starting in third grade through eighth grade and once in high school. Schools that had students who failed to show “proficiency” were subject to serious repercussions.

Nevertheless, as the number of ELs increases in our nation, states must require ELs, who are still trying to learn English, to meet the established standards and show mastery on English content-area exams for promotion and/or graduation (Short, 2002). It is no secret that Texas, like California and Florida, is a standardized assessment giant, administering the State of Texas Assessment of Academic Readiness (STAAR) in order to monitor the progress of every Texas student in the areas of reading, writing, math, science, and social studies in different grade levels beginning in the third grade. While some STAAR assessments are offered to ELs in their second language (e.g. Spanish) in grades 3, 4, and 5, the rest of the STAAR exams are not, and data shows there are existing achievement gaps between ELs and their native English counterparts. These achievement gaps continue to widen as the grade level increases (Migration Policy Institute, 2018).

In an effort to increase test scores and conceptual understanding in the core subject areas, the development of academic language in English is often left by the wayside with the hopes of

miraculously achieving cognitive academic language proficiency through osmosis leaving teachers without the knowledge of how to integrate literacy instruction into the content areas as well as build the scientific literacy need for careers in the areas of science, technology, engineering, and mathematics (STEM) (Tong et al., 2014). In this current age of accountability, schools, in states where testing is the end all, be all of success, struggle to find ways to effectively instruct ELs while increasing academic proficiency. As such, inadequate practices preemptively set our ELs up for failure due to the increasingly complex texts and high-stakes testing requirements in many content areas such as reading, mathematics, social studies, and science. For example, in order to master the New Generation Science Standards (NGSS), which now require students to make connections between science and communication, educators are facing a variety of challenges to grow English language proficiency as well as science content fluency (Weinburgh et. al, 2014).

It must be reiterated that because of the increasing number of ELs in the United States, specifically in Texas, there is an urgency to identify effective ways in which ELs can successfully learn content in the STEM subject areas, due to these individuals being alarmingly underrepresented in the careers of STEM in comparison to their Asian and white peers (Patchen, Zhang, & Barnett, 2016). Furthermore, science has been identified as an efficient discipline that can support language development as it allows authentic opportunities for discourse through inquiry (DiRanna & Gomez-Zwiep, 2013). In addition to this, with the changes in the Next Generation Science Standards (NGSS), an emphasis in communication skills and language development has been made; thus, making it necessary for teachers to build an environment where an integration of language learning and content knowledge is seamless (Hakuta, Santos & Fang, 2013). Whereas before, these standards were only concerned with what the “students

would know”, the NGSS explicitly promote the idea that students utilize the language skills necessary to convey their knowledge (DiRanna & Gomez-Zwiep, 2013).

When instruction is streamlined in such a way where the content area standards provide opportunities for the development of literacy, teachers are able to maximize instruction and students become strategic readers to facilitate their understanding (Moss, 2005). The problem and challenges exist when there is a lack of teacher efficacy as most find it difficult to integrate language-based activities within hands-on scientific exploration and successfully incorporate both language and content objectives into their lessons to promote literacy (Tong et al., 2014; Luster, 2012). Fisher and Ivey (2005) state that the problem stems from content area teachers resisting the strategies researchers have stated will help incorporate language and content. Thus, with the lack of effective teacher implementation, lack of language proficiency in English, and increasing test failures in the area of science, a negative cycle is perpetuated in the lives of ELs when they interact with the science content area. This inefficiency could be reversed if teachers practiced the integration of literacy and content instruction as should be often motivated to want to learn to read from the content they are enjoying to learn (Moss, 2005).

Ultimately, these challenges could potentially disengage and proliferate unmotivated individuals to pursue a career in the science field. While the *National Science Standards* state, “Science is for all students” as one of its guiding principles (National Research Council, 1996, p. 19), the reality is it has been a well-known concern that ethnically diverse students often score lower than their mainstream peers on science assessments (Tong et al., 2014). According to the 2015 National Assessment of Educational Progress (NAEP) data, the Hispanic student group received a “below basic” scale score of 121, while their Native English speaking peers scored a “below proficient” score of 158 (NAEP) (NCES, 2015a).

Thus, it is crucial educators prepare minorities, specifically English learners (ELs) for careers in these content areas, specifically science. Only by engaging them to their utmost potential and fostering their academic language development to achieve conceptual understanding will an increased interest in the sciences help ELs begin to close the achievement gap between themselves and their white peers. This must start as early as elementary schooling (Moss, 2005).

### **Definition of Terms**

#### **ELs or ELLs**

According to The Glossary of Education Reform, English-language learners, or ELLs, are students who not yet fluent or able to communicate or learn successfully in English (Glossary of Education Reform, 2013). Educators often use numerous terms when referring to English-language learners, including, but not limited to, English learners (ELs), limited English proficient (LEP) students, language-minority students, non-native English speakers, bilingual students, or emerging bilingual students (Glossary of Education Reform, 2013). The state of Texas uses the term English Learner (EL) to identify a student of limited English proficiency and whose native or primary language is other than English (TEA, 2018). While the many terms aforementioned may be used interchangeably to refer to a student who has difficulty performing classwork in English due to their limited English proficiency, for the purpose of this dissertation, we will use the term English Learner (EL) when speaking of these students.

#### **Former ELs**

Students who are reclassified as English proficient (EP) after having been initially classified as an EL, have exited an approved bilingual education program provided by the school

district after meeting an appropriate “exiting” criteria (Texas Education Agency, 2018). In the state of Texas, ELs are reclassified as EP after a committee, known as the Language Proficiency Assessment Committee (LPAC), comprised of administrator(s), bilingual teacher(s), parent representative(s), convene to review scores on an approved oral language proficiency test, norm-referenced standardized achievement reading test, and agency-approved writing test (Texas Education Agency, 2018). If, along with the aforementioned assessments, a subjective teacher evaluation, and parental approval, the EL meets the exiting criteria, he or she is reclassified as EP and is referred to as a former EL (Texas Education Agency, 2018).

### **Native-English Speaker**

For the purposes of this dissertation, the term Native-English speaker (NES) will refer to any student who was not classified as EL. This is important because on the Texas-Mexico border there may be students who speak Spanish at home, but by the time they reach school-aged appropriate grades, may have developed native-like English abilities and not identified as an EL or qualified for a bilingual education program by the process or oral language proficiency test administered by the school district.

### **Oral language Expression**

Oral language expression has many forms, both informal, Basic Intrapersonal Communicative Skills (BICS) and formal, Cognitive Academic Language Proficiency (CALP) (BOOK, 2017). BICS language is typically acquired between 2-3 years and is referred to as playground language; still, BICS language is important and needed for ELs to participate in general conversations (Cummins, 1991). CALP language takes longer to acquire, between 5-7 years typically, and is referred to as academic or school language which is crucial for ELs to attain in order to participate in classroom discourse (Cummins, 1991). Sometimes referred as



oral language proficiency, oral language expression is the term that will be used to describe ELs engaging in both BICS and CALP in informal dialogues as well as academic, instructional conversations.

In a broader context of oral language expression, Wilkinson (1965) refers to the role of oral language in the classroom as *oracy* and defining it as “the ability to express oneself coherently and to communicate freely with others by word of mouth”. Furthermore, Wilkinson expressed the need for the development of oracy as it built a foundation for reading and writing skills.

### **Vocabulary Knowledge**

For ELs vocabulary knowledge is essential for continued reading success and academic achievement (Frumkin, 2010). Because vocabulary knowledge is not simply knowing a word, Cronbach’s (1942) description of word knowledge assists in understanding the dimensions of having this skill (Beck, et al., 2002). The dimensions are as follows:

- *Generalization*: The ability to define a word.
- *Application*: The ability to select or recognize situations appropriate to a word.
- *Breadth*: Knowledge of multiple meanings.
- *Precision*: The ability to apply a term correctly to all situations and to recognize inappropriate use.
- *Availability*: The actual use of a word in thinking and discourse.

### **Content Area Instruction**

Content-area or subject-area instruction, is instruction of the disciplines: reading, writing, mathematics, science, and social studies alike. This focus of this instruction is content

knowledge. That is to say the acquisition of content knowledge and skills in that particular content area is of utmost importance. It is important to point out that there is a difference between Content-area instruction and pedagogical approaches such as: Content Language Integrated Learning or Content Area Literacy.

### **Content Language Integrated Learning**

Content Language Integrated Learning (CLIL) is a pedagogical approach in which literacy is embedded within the content area. True attention is paid to the language demands required to make content comprehensible and attainable.

### **Content Area Literacy**

Content Literacy is a newer term to refer to the integration of literacy and the instruction of content (Fisher & Ivey, 2005).

### **Student Talk**

Student talk or classroom talk refers to discourse in any language that occurs in the classroom. People were born to talk (Hulit, Howard, & Fahey, 2010); however, researchers have noted that student talk is often limited and used as a form to monitor comprehension rather than develop thinking (Fisher & Frey, 2014). What is more, teachers frequently dominate the talk. Examples of student talk in the classrooms can be, but are not limited to discussions, reflections, clarifying understanding, or reciprocal teaching (Fisher & Frey, 2014). These interactions can be defined as situations where discourse is exchanged between students and/or between teachers and students.

### **Scientific Literacy**

Initially, the area of focus when teaching and learning the science discipline involved students simply demonstrating their knowledge of content, and while this may still be the case in

some classrooms, the emphasis and critical aspect of science learning and scientific literacy involves effectively communicating (talking, reading, and writing) the discipline; ultimately, being able to access the content while demonstrating the discursive, literacy skills to engage in the content (Moje et al., 2004). According to the National Science Education Standards (NSES), scientific literacy requires a knowledge and comprehension of “scientific processes required for personal decision making, participation in civic and cultural affairs, and economic productivity” (National Research Council, 1996).

An achievement of this scientific literacy provides a pathway for students to have opportunities to attain STEM driven 21<sup>st</sup> century careers (Luby et al., 2016). A career in STEM would require a literate citizen to be able to evaluate scientific information, the source and the methods used to generate said information, while posing and/or evaluating arguments based on scientific evidence to draw conclusions (DeBoer, 2000).

### **Science Inquiry Framework**

While a variety of instructional models have been utilized and promoted to be utilized in the development of science inquiry, the instructional model employed in this randomized study of a literacy-infused science curriculum is known as the 5-E model (Engage, Explore, Explain, Evaluate, and Elaborate) developed by Roger Bybee (Tong et al., 2014). In this instructional model, the lessons are designed to (a) activate students’ prior knowledge through the *Engage* phase, (b) help students discover a new phenomenon through the *Explore* phase, (c) have students construct a way to elucidate their thinking in the *Explain* phase, (d) develop ways for students to apply their thinking and learning in the *Elaborate* phase, and (e) allow students to justify how their thinking has either been confirmed or modified with the scientific concepts studied through the *Evaluate* phase (DiRanna & Gomez-Zwiep, 2013).

## **Conceptual Understanding**

Content-area knowledge is simply the knowledge on a particular topic (Hirsh, 2006); nonetheless, when we address conceptual understanding of any content area, it really is the application of knowledge across disciplines and through various modes of communication. In the area of science education, conceptual understanding, simply put: it is the ability to use science knowledge (Huerta, 2013).

## **Two-way ANCOVA**

A statistical analysis, the two-way analysis of covariance (ANCOVA), also known as a “factorial ANCOVA” is used to determine if there is an interaction effect between two independent variables on a dependent variable when adjusting or controlling for a covariate (“Two-way ANCOVA in SPSS Statistics,” n.d., Introduction section, para. 1)

## **Chi-Square Analysis of Homogeneity**

This statistical analysis compares the frequency of responses from two or more populations regarding a dichotomous variable. When it is determined that the differences between the two or more groups, then one could use another statistical analysis, Cramer’s V, to establish the effect size for the Chi-Square test (“Test of Homogeneity, Chi-Square,” 2008).

## **The Rio Grande Valley**

According to Ryabov & Merino (2017), Texas is the second largest state by population size in the country and its demographics have an enduring impression on the nation as a whole. One particular area, the Rio Grande Valley (RGV, or, the Valley) is located on the southernmost tip of Texas and comprised of four counties — Cameron, Hidalgo, Starr, and Willacy (Ryabov & Merino, 2017). The RGV is not only one of the fastest growing areas in the United States, but

also reported as poverty stricken leading the nation in the highest number of reported unemployment and low income (Ryaboy & Merino, 2017).

### **Statement of the Problem**

It is certain that the education of ELs or non-English speaking students has come a long way since *Lau v. Nichols* (1974) ruled for an equal protection of eighteen hundred Chinese-American students receiving education at a public school in San Francisco, California. After *Brown v Board of Education* (1954) ruled that “separate but equal” was not good enough, *Lau v Nichols* emphasized the fact that “equal” was not necessarily “equal” when providing students with the same facilities, textbooks, teachers, and curriculum (Hornberger, 2005). Regrettably, while *Lau v Nichols* shed light on this underlying disparity, it failed to specify a program to effectively educate the growing number of immigrants and EL learners in the nation (Hornberger, 2005).

According to the U.S. Department of Education, ELs are recognized as a large population whose numbers have increased in more than half of the nation’s states, approximately 10% of the total student population with a vast majority of ELs identified themselves as Hispanic or Latino (National Center for Education Statistics, 2017). Whereas the number of ELs and the education of these students was a greater urgency in the gateway states, such as California, New York, and Florida, it has now become a concern nationwide with many states, such as North Carolina, experiencing a 500% increase in their EL population between the years 1993-2003 (Bravo & Cervetti, 2014).

Nevertheless, with all the attention that is being placed on educating ELs throughout our nation, these students continue to perform well below their native-English speaking peers in the

content areas, specifically, science. According to the Nation's Report Card, the most recent data (2015) regarding student achievement-level results for fourth grade students assessed in science indicated that the percentages of ELs scored at or above the basic and proficient levels was higher than the 2009 data (National Center for Education Statistics, 2015). However, ELs scored thirty-one percent below non ELs. Also, 20% native English speakers scored below basic levels, while nearly 40% more ELs scored a below basic level (National Center for Education Statistics, 2015).

This achievement gap only widens as ELs move up throughout their education career. In 2015, students who were eighth graders and were assessed in Science scored significantly below their native-English peers (National Center for Education Statistics, 2015). Eighty-one percent scored a below basic science proficiency level; almost 52% below non-ELs (National Center for Education Statistics, 2015). Four percent of ELs in 2015 demonstrated science proficiency in comparison to the thirty-four percent of native-English speakers (National Center for Education Statistics, 2015). Recent data from the state of Texas mirrors what is occurring nationwide. In the content area of Science, "ELs scored on average 16 points lower than all students in grade 5 and 28 points lower in grade 8" (Migrant Policy Institute, 2018).

While there is no direct link that can be made from low science proficiency scores in ELs and their participation in pursuing careers in STEM, it stands to reason that these ELs underperforming in the area of science are less likely to follow a career in the STEM disciplines of science, technology, engineering, and or mathematics when they do not have the proficiency (Bailey et al., 2018). Still, these achievement gaps continue to grow, and our blame is misplaced when educators should be implementing ways in which ELs could simultaneously attain the

vocabulary of scientific literacy and the ability to effectively communicate the complexity of scientific concepts.

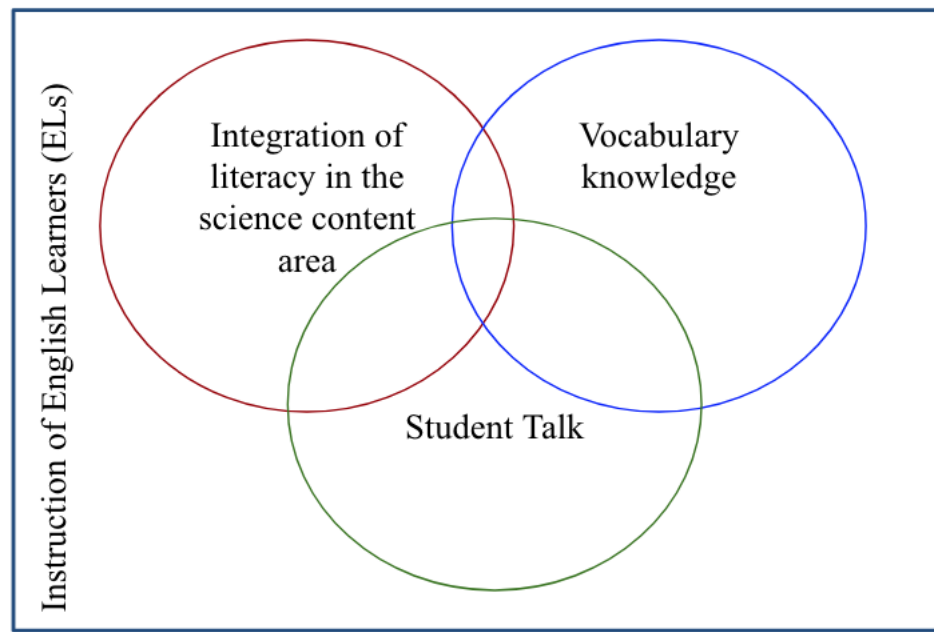
### **Theoretical Framework**

This theoretical framework is structured on three focal points which researchers have continuously shed light on as methods towards providing effective instruction and improving student achievement for ELs throughout the content areas, and specifically, science. The first is the integration of literacy in the content areas. Researchers have indicated that literacy instruction in the content areas creates intentional and purposeful opportunities for ELs to develop in the literacy domains of listening, speaking, reading, and writing. Such areas are crucial to the development of scientific literacy and ultimately, attaining a career in the STEM disciplines.

In congruence with content area and literacy instruction is the knowledge of important terms of the context therein. Vocabulary knowledge is vital to the comprehension of text, narrative, and informational which is often found in the content-areas (August et al., 2016). In content areas, such as science, where students must make sense of language that occurs in context-reduced academic situations, ELs are often at a disadvantage in comparison to their native English peers; thus, according to Marzano and Pickering (2005), there is an increase to the 83<sup>rd</sup> percentile when direct vocabulary instruction of content area words is taught. Instruction where vocabulary development is communicated through meaningful and purposeful classroom opportunities benefits EL's English language development.

The third focal point in this theoretical framework is student talk. Through the expression of language, by student talk and purposeful classroom discourse, students can truly process their thinking and challenge, defend, and express themselves to become active learners

in their learning (Fisher et al., 2008). These three focal points will be addressed below to establish the theoretical viewpoints and analysis relevant to the research problem in this investigation. *Figure 1* helps provide a visual of my conceptual framework.



*Figure 1:* Conceptual Framework for Effective Instruction of ELs

### **Content Area Instruction**

Content area instruction or subject area instruction is defined as instruction of the disciplines: mathematics, reading, science, and social studies, and now, more than ever before, researchers are exploring how to effectively provide content area instruction for ELs as the achievement gap between them and their native English peers appears to widen (Janzen, 2008). This gap is evident when ELs must engage in informational text to understand in the content-areas (Watkins & Lindahl, 2010).

Content area instruction often requires background knowledge to understand the content or content-area text as well as challenges ELs to decipher the structure of the syntax which often connects ideas (Brown, 2007). Historical texts, for example, are often written passively causing



confusion as ELs are often not familiar with this form of discourse (Brown, 2007). Additionally, Brown (2007) states that content-area instruction includes ideas which often may be dense and convoluted in a manner which can be too complex for ELs to sift through and derive the main idea. ELs face this type of content-area instruction in a myriad of classrooms daily and majority of the students who do not develop the necessary skills to tackle these content area texts may never recover (Moss, 2005).

Of course, while the causes of academic failure of this specific population are multidimensional, one could argue that the simple thought processes of content-area teachers and the requirement of including literacy in their instruction pose the first hurdle in adopting an effective “content-area literacy” approach for our EL population.

### **Not Every Teacher a Language Teacher**

Many content-area teachers pose the argument that the responsibility of implementing literacy activities such as learning vocabulary, the application, breadth, precision, and availability: or actual use, falls solely on the English language arts teacher (Fisher & Ivey, 2005). Such thinking limits the opportunities for ELs to engage in activities which may create connections between language and content ultimately making it difficult for ELs to access the content. The implementation of literacy within the content areas is more often than not met with a hard and steady word: resistance (Buckingham, 2012). Content area teachers justify their resistance to include opportunities for the development of literacy in their content areas by stating that they are waiting for their turn so that opportunities for math and science be included in every content area (Buckingham, 2012).

In addition to the resistance, is the training most content-area teachers lack to the requirement of embedding literacy in their respective content areas. Sadly, while many

educators have been taught some general content literacy strategies to include while teaching their content, most have not been taught how to include discipline-specific literacy applications (Fisher & Frey, 2015). According to Topping et al. (2006) in the year 1994 only 28 percent of “public school teachers with English-language learners in their classrooms had undergone any training” and over 41 percent of public school teachers reported feeling ill-equipped to teaching ELs on a schools and staffing survey.

Thus, with the lack of understanding and training for content-area teachers to be prepared to embed discipline-specific literacy applications within their instruction, it comes with no surprise that the education of ELs continues to be an area of growing concern. With many teachers resistant to the integration of literacy in the content areas and the lack of training on how to effectively integrate literacy within the subject areas, the question still remains as to how to approach the issues of content knowledge and the ever-growing educational gap between ELs and their peers.

### **Content Area Literacy**

Conner et al. (2010) state that researchers and practitioners have suggested teaching students the literacy skills needed while teaching content (e.g. science, social studies) could possibly help increase their content knowledge. This literacy-integrated approach maximizes instruction for the growing number of ELs in the nation’s classrooms (Barber et al., 2015). Content area literacy or content literacy supports the idea that students are engaged in content to “construct and co-construct knowledge through activities such as discussion and reading and writing from multiple perspectives” (Fisher & Ivey, 2005). This approach is more student centered and constructivist oriented; however, inconsistent with traditional content-area teachers (O’Brien, 1995). As Thompson (2004) states there is a complex process embedded when ELs

are learning grade-level content and English. Given the complex, linguistic and assessment challenges that are involved with ELs, we cannot afford to waste more time ignoring effective content-area instruction.

Content-area literacy encompasses recognizing the cognitive demands that are specific to the content and then including discourse opportunities to develop skills in the areas of speaking, listening, reading, writing and thinking (Meltzer & Hamann, 2006). Furthermore, content-area literacy incorporates a large attention to the informational texts and text structures needed for building conceptual understanding (Meltzer & Hamann, 2006). It is no mystery that if teachers want students to think like scientists, write like scientist, or speak like scientists, that we provide opportunities for students to practice doing so in the classroom (Meltzer & Hamann, 2006). This requires student to demonstrate their ability to utilize their communicative skills necessary to exhibit English language proficiency and content knowledge.

Literacy, then, plays a critical role in facilitating students' comprehension of the content-areas; hence, academic language, an integral piece of literacy instruction, must be explicitly and consistently taught, utilized and modeled by the teacher, as well as articulated through students' thinking processes in order to maximize student learning of the content-areas (Janzen, 2008).

### **Academic Language**

It is our schools and teachers which have the responsibility of making sure our students leave the classroom prepared with the social and academic language skills necessary to participate and compete globally as citizens of the world (Taboada, 2009). Particular language skills are necessary in order to be successful in the classroom and in life. Since 1991, Cummins has identified and distinguished between two types of language skills: Basic Interpersonal Communicational Skills (BICS) and Cognitive Academic Language Proficiency (CALP). BICS

are often referred to as everyday conversations or interactions. Taboada (2009) characterizes BICS as “context-embedded communication”. That is to say, the application of BICS relies on the individuals involved to share similar oral language skills, experiences, or engage discourse involving in day to day tasks.

CALP, on the other hand, involves utilizing a set of language skills necessary to engage in more academic or cognitively demanding discourses (Taboada, 2009). This are characterized as “context-reduced” forms of communication. Utilizing CALP would be required while reading an informational or expository text or textbook, listening to lectures in a particular content-area, giving a speech in which no immediate or explicit context has been given (Taboada, 2009). While both BICS and CALP are necessary, the language skills needed to function well in a school context, specifically in the content-areas, is CALP.

### **Content-Area Specific Vocabulary.**

In every content-area there exists specific vocabulary terms required to develop conceptual understanding and negotiate the terms in complex classroom tasks (Meltzer & Hamann, 2006). It is essential, then, that teachers deliberately help their students acquire and learn these terms in order to increase content learning as well. Taboada (2009) further addresses the need for ELs to develop content-area specific vocabulary in order to access complex texts with the subject area. Regrettably, at times, there may be little emphasis on vocabulary instruction (Beck, et al., 2002) and limited opportunities for students to participate in authentic classroom contexts which provides frequent interaction with informal and formal vocabulary or even content-specific vocabulary.

Content-area specific vocabulary can also be identified as “brick” words. These vocabulary words are specific to the content and concepts being taught in the unit. The

counterpart is “Mortar” words. These words are also considered academic vocabulary, but they are usually cross-curricular and general (e.g. therefore, analyze, describe).

The decontextualized form of communication students should be engaging in the classrooms and throughout the content-areas requires that teachers present opportunities for students to develop CALP whenever possible. The content-specific vocabulary and general, academic vocabulary words may be unfamiliar to ELs and having opportunities to listen, speak, read and write “brick” and “mortar” words. CALP encompasses not only the academic vocabulary needed, but the true discourse required in real-world applications, or in the content-area of science, and furthermore, in STEM careers.

### **Scientific Vocabulary**

Bravo and Cervetti (2014) state that “without instructional attention to language within content areas, like science, ELs will not develop the type of academic register they need to fully engage in the discipline and be career and/or college ready”. Lee and Luykx (2005) also state that without proper support, the linguistic demand required in the science content area can impede ELs’ conceptual understanding. They must have the vocabulary to tackle informational texts, such as those found in the content areas (Shanahan and Beck, 2006). Science vocabulary, moreover, includes a variety of words with which students may be familiar with, but in actually have a more academic meaning (e.g. current, dense, wave) (Bravo & Cervetti, 2014).

Because ELs face the arduous task of developing their English language proficiency while acquiring the scientific knowledge, including but not limited to, the appropriate scientific terminology, educators must provide “linguistic scaffolding” when engaging in dense science tasks such as laboratory reports and experimental tasks (Bravo & Cervetti, 2014). This “linguistic scaffolding” should not dilute the content, rather, make it comprehensible and extend

opportunities to incorporate scientific vocabulary through listening, speaking, reading writing activities in the classroom.

### **Relationship between Content and Language**

Is there really a relationship between content and language? Researchers believe so. A closer look at fourth grade students and their literacy achievement tells a story commonly referred to as the “fourth grade slump” or “fourth grade cliff” (Fang, 2006). This phenomenon has been attributed to the shift in reading predominately narrative texts in the lower elementary grades to more exposure to informational, expository texts in the upper grades (Fang, 2006). Scholars have suggested that lower elementary narrative texts often utilize vernacular that is basic, social, and for everyday use (BICS) while expository, content-area or informational texts include a specialized language of academic subjects (CALP) which is often less utilized and uncommon to students (Schleppegrell, 2004).

The relationship is then if opportunities can be provided within the content-areas to promote the development of cognitive academic language in the areas of listening, speaking, reading, and writing, the implications for science learning for all students, specifically for ELs, is great.

### **The Role of “Student Talk” in Developing Conceptual Understanding and Language**

Language is how we think, process information, and remember (Fisher et al., 2008). Still, in most classrooms, teacher-led discussions, teacher-centered discourses and questioning, and teacher-led decision making are what is evident and practiced (Lesko, 2019). In a study by Lingard, Hayes, and Mills (2003), they discovered that teachers talked more and students talked less in classrooms in which there were higher numbers of students living in poverty. While not all ELs are poverty-stricken, we also know that typically, these students are asked less questions,

or none at all, making it very difficult to “student talk” in the classroom at all (Fisher et al., 2008).

If we want students to analyze, synthesize information and evaluate scientific content, then teachers must place emphasis on ways teaching and learning science involves effectively communicating (talking, reading, and writing) the discipline. If, according to the National Science Education Standards (NSES), scientific literacy requires a knowledge and comprehension of “scientific processes required for personal decision making, participation in civic and cultural affairs, and economic productivity”, then our students must participate in authentic conversations to truly engage students and their thinking (National Research Council, 1996).

As Fisher et al. (2008) states, learning is not a passive experience where students’ best learning experience is to listen to the teacher “talk and tell” all day. Students, specifically, ELs should have many opportunities to take ownership of their thinking and confirm or deny their conceptual knowledge based on the academic conversations *facilitated* by the teacher (Fisher et al., 2008). The state of Texas, in its recent updates to the English Language Arts, Texas Essential Knowledge and Skills (TEKS) developed standards under a new strand called, Response Strand in which students are expected to respond to multiple text by listening, speaking, reading, writing, and thinking (Texas Education Agency, 2017). One student expectation even further addresses the need for students to respond “using newly acquired vocabulary as appropriate” (Texas Education Agency, 2017). Hence, the message received from standards based teaching is that opportunities to interact and respond to the content through a variety of multiple texts and genres being taught is necessary.

Ultimately, learning is essentially a social process and talking to one-another gives students an opportunity to lead one another to inquiry and investigation during content-areas such as science (Lemke, 1990). While some may argue that students regularly use colloquial language, simple, commonsense wording for scientific processes, Lemke (1990) stresses the need for educators to foster this colloquial language and help students build scientific literacy through science talk or “classroom talk”. This “classroom talk” will increase students’ fluency and flexibility in using scientific language (Lemke 1990).

### **Research Overview**

A focus on teaching the content areas, specifically science, through a content reading integration or what is now known as content-area literacy approach for ELs provides an effective method to increase student achievement while promoting the development of the English language (Frumkin, 2010). If ELs are demanded to attain scientific literacy and are sought out to achieve employment in the STEM careers, teachers are required to provide opportunities for the development of literacy skills within their content areas (e.g. Reading comprehension in the content areas is necessary for conceptual understanding and application.) (Brown, 2007).

Often “content-area instruction” is usually a term associated with middle school and high school classrooms because of the structure of the schools; thus, the content-area literacy approach in the lower elementary grades are few (Bravo & Cervetti, 2014). Moss (2005) makes a case for content-area literacy instruction to begin at the lower elementary grades so that by middle school, the reading demands would not burden our ELs. One study, Kamil and Lane (1997) observed how a first-grade classroom embraced expository texts, and through their engagement became increasingly able to navigate informational texts and writing abilities



improved; still, there are a small number of researchers that have observed the development of oral language and vocabulary when a literacy-infused, inquiry-based science intervention was utilized with fidelity.

### **Purpose of the Study**

The purpose of my study is to examine the impact of a literacy-infused, inquiry-based science intervention and ELs' expressive oral language and English vocabulary development on pre-and post-assessments, with a focus on a Texas-Mexico border school district. In order to further examine these inquiries, I will commission both quantitative and qualitative techniques. The quantitative will utilize an ANCOVA analysis to evaluate what effect the literacy-infused science intervention had on the treatment group in comparison to the controlled group in the areas of oral language expression and vocabulary skills. This study will delve deeper into the results from a larger study, ELLA-V, and take a closer look at the oral language and vocabulary skills attained by a group of third graders participating in a literacy-infused, science intervention in a high-interest, high needs area, the Texas-Mexico border.

In addition to this quantitative measure, the qualitative portion of my study will consist of an analysis of teacher recorded videos and the content therein. This analysis of teacher recorded videos and student engagement is to focus on an additional portion important to the development of English language proficiency: student-talk. Because we know that the content and language are inseparable, it is essential that educators purposefully include opportunities in the classroom that simultaneously develop language and content knowledge (Hakuta, Santos, & Fang, 2013). Therefore, an additional layer, a look at "student-talk" and the level of discourse in the classrooms could provide some insight as to how teachers help ELs unpack language skills while developing a greater understanding of the content (Hakuta, Santos, & Fang, 2013).

## **Research Questions**

The following four questions guided my study:

1. Based on the implementation of a literacy-infused, inquiry-based science curriculum in a Texas-Mexico border school district, to what extent is there a difference between English vocabulary skills of ELs in the treatment group versus the English vocabulary skills of ELs in the control group as measured by the Woodcock Muñoz Survey-Revised picture vocabulary subtest?
2. To what extent is there a difference between the English oral language expressive skills of ELs in the treatment group versus the oral language expressive skills of ELs in the control group as measured by the Woodcock Muñoz Survey- Revised verbal analogies subtest?
3. Is there a difference between male and female ELs in oral language expressive skills and English vocabulary as measured by Woodcock Muñoz Survey-Revised picture vocabulary and verbal analogies subtests?
4. Is there a difference that exists between classrooms utilizing the literacy-infused, inquiry-based science curriculum and those who are not, in relation to “student-talk” and/or “teacher-to-student interactions” in either English or Spanish academic language?

### **Significance of the Study**

There is an increasing need to study ways in which our ELs can develop oral language proficiency in English and reading and writing skills in order to compete with their mainstream peers. Similarly, the achievement gap between ELs and their native English peers exists throughout all content areas such as Science, and national data suggests that the gap does not seem to be narrowing as they continue to grow in their educational career. This study will explore and contribute to the much-needed research in the field of science education and literacy from the EL Texas-Mexico border population.

### **Limitations**

In this present study, readers should be aware of some limitations when interpreting results. First, the sample included students from an area on the Texas-Mexico border who were identified ELs; however, some third-grade students may or may not have been present in U.S. schools since pre-kindergarten or kindergarten. The larger study did not focus on this factor; however, it is one to consider seeing that primary schooling in the United States and Mexico differ. Second, due to the high mobility rate of students in this region, it may be that some students were attending U.S. schools, but choose to cross the border and return or visit their families or extended families on the Mexico side during the treatment period. This would mean that opportunities to practice English language expression outside of the classroom could be further limited. Again, the larger study did not choose to further investigate this issue.

## **Assumptions**

An assumption of the present study is that all teachers were aware of the demands and implementation of the CRISELLA grant. Fidelity to the program and its components is an important assumption to make as it is necessary for the results to be included in as a part of the literature to benefit ELs. Through observations conducted as a part of the larger study, researchers made note that the school district involved in the present study was faithful to the implementation of the treatment intervention.

## **Organization of the Study**

Chapter I of my study establishes the context by which this study is based. It is comprised of a background on ELs, a definition of important terms, statement of the problem, the theoretical framework, purpose of study, the research questions which guide my study, the significance of the study, and limitations, and assumptions.

Chapter II of my study includes an introduction, content-area literacy instruction, literacy-infused, inquiry based science instruction in the middle and elementary grades, gender issues in regards to learning language, and exploring the value of student talk, and a conclusion.

Chapter III of my study includes an introduction, description of the sample and research design, instrumentation, intervention procedure, data collection, data analysis, and a summary.

Chapter IV of my study reports data analysis and summary.

Chapter V of my study presents a discussion of the findings and significance, limitations, conclusions, and recommendations for the future.

## **CHAPTER II**

### **REVIEW OF LITERATURE**

In order to initiate my systematic literature review, I listed the terms that would best define my participants, intervention, comparison, outcomes, and preferred method of study design. In meeting with the university librarian specialist, we discussed the population of focus: ELs, the need to search for interventions concerning or discussing content-area reading, literacy in the content areas, and examining the impact of the intervention in and between participating and non-participating groups in pre- and post-assessments in the areas of oral language and vocabulary development. Other focuses for the systematic literature review were gender differences and student discourse and/or student talk throughout science classrooms.

Once the appropriate terms were defined and discussed, I posed four questions to guide my research strategies and organize my findings: 1) What does the current literature say about content area reading interventions and ELs' oral language expression and vocabulary development?, 2) What does the current literature say about content area reading interventions and ELs in STEM classrooms?, 3) What does the current literature say about the differences in gender in regards to ELs and STEM?, and finally, 4) What does the current literature say about "student-talk" and "teacher-student interactions" in content area literacy interventions? These questions helped me shape my understanding of the available literature from the year 2001 to the current year, 2019.

This purpose of this systematic literature review is to establish a context of the current works in regards to (a) the impact of content-area instruction and curriculum on student achievement for ELs, (b) the impact of content-area instruction and curriculum on student achievement for ELs in the area of oral language expression, (c) the impact of content-area

instruction and curriculum on student achievement for ELs in the area of vocabulary, (d) the impact of content-area instruction and differences between gender, ELs, and STEM classrooms, and (e) the impact of “student talk” and “teacher-to-student interactions” on the development of oral language and vocabulary.

### **Eligibility Criteria**

In order to determine which literature was current and relevant to my research interest, I developed an eligibility criteria by which all the publications that the search strategies would populate needed to meet. The following is the listed criteria:

1. The publication must have been initially written or translated into the English language.
2. Only studies in the US were considered.
3. Included publications published in 2001 or later.
4. Only literature involving English Learners in some capacity was used.
5. The publications must have included all key variables in some form: content area-instruction, oral language, vocabulary, “student talk”, gender and ELs, and STEM instruction.
6. When researching “student talk”, publications included could utilize synonyms such as discourse, interactions, and discussions.
7. Studies published in journal article format, dissertations, and reports were considered eligible.

## Search Process

To begin exploring my research interest, an initial search through the ERIC (Education Resources Information Center) database under EBSCO, an online library of research and information in the educational field, was conducted utilizing a combination of key words such as content area reading, content integrated, curriculum development, and English language learners. This yielded a result of 34 articles. Of these thirty-four articles only 8 were included as possible contributing literature due to the population and overall focuses of the studied. It was clear that the search needed to be widened and key words adjusted. The following is the search strategy used in ERIC:

DE "Content Area Reading" OR TI ( ("content area" or "content integrated" or science or "content knowledge") n3 (literacy or reading) ) OR AB ( ("content area" or "content integrated" or science or "content knowledge") n3 (literacy or reading) )

AND

( (DE "Curriculum Development") OR (DE "Course Content" OR DE "Curriculum Design" OR DE "Curriculum Enrichment") ) OR TI Curricul\* OR AB Curricul\*

AND

DE "English Language Learners" OR TI ( english language learner\* or ell or esl or english as a second language or second language learning ) OR AB ( english language learner\* or ell or esl or english as a second language or second language learning )

Rather than limit the search to English learners, the term “Hispanic American students” was used. This term was synonymous to English learners within the ERIC and Education Source databases. Also, to locate research regarding oral language expression and vocabulary, another search was done using key terms and connectors (i.e. oral language development, vocabulary, and content area reading). Because the search included dates from 1986 to 2019, this yielded 4,059 results. Results included dissertations, journal articles, books, reports, etc. A refined search to include literature within approximately the last twenty years (2002-2019) was done. From the large amount of 4,059, the search was narrowed down to 2,662.

This second search was still too large, so in order to filter through the journal articles, dissertations, reports, and such, the search was limited to only those studies conducted in the United States, in elementary and middle school grades, and within the last seventeen years. The search strategy also was adjusted to use three search strategies to combine the following descriptors: Hispanic American students OR English language learners, content area reading, oral language and vocabulary development. Once combined, the search strategy yielded 89 items to be reviewed including reports, academic journals, Eric documents, books, and dissertations. The following is the search strategy used in ERIC:

S1

DE hispanic american students OR english language learners OR TI ( “latina student\*” OR “latino student\*” OR “hispanic american student\*” OR “latino” OR “English language learner\*” ) OR AB ( “latina student\*” OR “latino student\*” OR “hispanic american student\*” OR “latino” OR “English language learner\*” )

S2



DE content area reading OR TI ( "content area reading" OR AB ( "content area reading" )

S3

DE vocabulary development OR TI ("Reading and Literacy" OR reading OR literacy OR "vocabulary development" OR "oral language development") OR AB ("Reading and Literacy" OR reading OR literacy OR "vocabulary development" OR "oral language development" )

An identical search strategy was conducted on Education Source, another database reliable to store educational themed research. A first search was conducted to look for any information or research on Hispanic American students or Latino students. A second search delved into information regarding content area reading. A third search filtered research regarding vocabulary education in elementary schools or oral language development. A combination of these search strategies yielded 14 results. Approximately 7 articles were also included in the search done in ERIC; thus, a final total of 7 were reviewed from Education Source. Additional articles were gathered from the experts referenced in the articles of the original searches. These articles were also reviewed and categorized.

It must be mentioned that while current and relevant studies were sought (e.g. 2002-2019), additional articles of earlier dates written by or featuring experts in the field were included due to their established, valuable research, including, but not limited to, Cummins, Becks, et al., and Vygotsky. Ultimately, of the 103 articles gathered through the databases and references, only 37 were included for further review and referencing ranging from 2001 to 2019 after screening titles and abstracts. After initially establishing a date range from 2002 to 2019, the search was changed from 2002 to 2001 in order to include any publication which could have

been made in response to The No Child Left Behind Act (NCLB) which was passed in Congress in 2001 and on January 8, 2002, was signed into law by President George W. Bush (Klein, 2015).

Additionally, to address the third question regarding gender and its interaction effect by condition another search strategy was conducted in ERIC. In this search strategy, the following key vocabulary words, terms, and/or phrases were used to gather as much information regarding gender, ELs, and content area reading interventions:

S1

DE hispanic american students OR english language learners OR TI ( "latina student\*" OR "latino student\*" OR "hispanic american student\*" OR "latino" OR "English language learner\*" ) OR AB ( "latina student\*" OR "latino student\*" OR "hispanic american student\*" OR "latino" OR "English language learner\*" )

S2

DE content area reading OR TI ( "content area reading" OR AB ( "content area reading" )

S3

DE vocabulary development OR TI ( "Reading and Literacy" OR reading OR literacy OR "vocabulary development" OR "oral language development" ) OR AB ( "Reading and Literacy" OR reading OR literacy OR "vocabulary development" OR "oral language development" )

This search strategy yielded 133 total results in which gender differences were found in peer-reviewed educational journals regarding ELs, content-area reading, vocabulary and oral

language development. Of the total, only four were included in this literature review due to the relevance to the study.

In order to make address the fourth literature review research question regarding student talk, discourse, discussion, or interaction, an additional search was done in both ERIC and Educational Source utilizing only the following search strategies:

S1

DE hispanic american students OR english language learners OR TI ( "latina student\*" OR "latino student\*" OR "hispanic american student\*" OR "latino" OR "English language learner\*" ) OR AB ( "latina student\*" OR "latino student\*" OR "hispanic american student\*" OR "latino" OR "English language learner\*" )

S2

"("student talk" OR "academic discourse" AND (science education or science teaching or science learning) )

S3

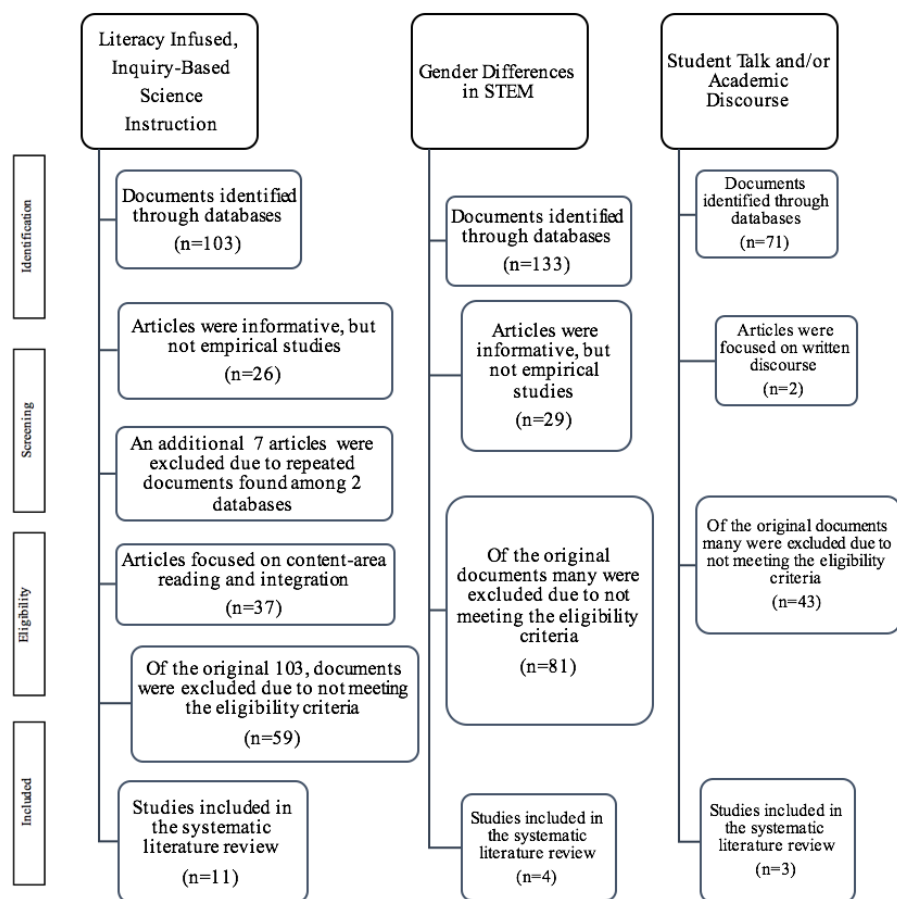
DE vocabulary development OR TI ("Reading and Literacy" OR reading OR literacy OR "vocabulary development" OR "oral language development") OR AB ("Reading and Literacy" OR reading OR literacy OR "vocabulary development" OR "oral language development" )

Again, the search was limited to only those studies conducted in the United States, in elementary and middle school grades, and within the year 2001 to 2019. Once combined, the search in ERIC yielded 73 publications. Of the 73 publications, a thorough search for relevance to “student-talk” and/or “teacher-to-student interactions” in either English or Spanish academic

language was sought for. Ultimately, three publications were included in this systematic literature review to address.

### Selection Process

In order to organize the findings from my systematic literature review, I used a PRISMA flow diagram as shown in *Figure 2* (Liberati, 2009). PRISMA is an acronym used for “preferred reporting items for systematic reviews and meta-analysis”.



*Figure 2: PRISMA Flow Diagram of the Systematic Literature Review*

After an in-depth review of these articles, all were then organized by its focus, content, and ultimately relevance. The following categories were created to help organize the information retrieved: (a) content area instruction (b) literacy-infused, inquiry-based science curriculum in middle and elementary schools, (c) gender differences in the STEM areas, and (d) student discourse in science classrooms. My ultimate purpose is to provide the fullest review of the literature of the following areas with a linguistic lens and for the benefit of ELs.

### **Content Area Instruction**

The largest sample of studies, reports, or journal articles the search strategies disclosed mainly focused on content-area instruction or what is now most commonly referred to as content-area literacy (N=37). Older articles which used the aforementioned term of content-area instruction were still utilized since they are valuable to the systematic literature review. These works were organized as either studies conducted (N=11) or background articles (N=26).

While the focus of our study will be on the science content-area, studies regarding other content-areas should be reviewed to examine what these studies were able to focus on and gather in order to develop conceptual understanding for ELs. This being the case, only 2 studies from the eleven focused on content-areas other than science. These studies will be address here and the others will be addressed under the literacy-infused, inquiry-based science curriculum portion of this systematic literature review.

Trainin et al. (2016) examined the impact of *QuickReads*' technology and print formats on fluency, comprehension, and vocabulary development for elementary students. Although this study does not solely focus on ELs, it places critical importance on the gradual release of responsibility (GRR) developed in 1983 by Person and Gallagher which is based on Vygotsky's

zone of proximal development (Trainin et al., 2016). This is vital to mention for the study because these are all strategies put in place to scaffold comprehension for the EL population. In this study, *QuickReads* provides several instructional sessions that lasts approximately 15 minutes in which teaching is gradually released (Trainin et al., 2016).

In the first session, the text is read-aloud by the teacher for an opportunity for modeling prosody, rate, expression, etc. In the second session, students silently read the text as the text is also read aloud again to show expression, prosody, and rate. In the final, third session, students read the text independently and under timed conditions. By the final read, these students would have already been exposed to the text and its complexity several times familiarizing themselves with the text and worked with the key vocabulary terms for greater understanding (Trainin et al., 2016). This study is important to note because the *QuickReads* text were all content-area texts involving science and social studies topics. Trainin et al. (2016) address the common and increasing issue that schools are reducing the amount of time spent in science and social studies; hence, it is critical that educators maximize the opportunities to integrate content area topics in instruction.

The results of this study showed that students in the treatment group classrooms who received the *QuickReads* intervention ultimately achieved “significantly higher scores in reading rate, comprehension, and vocabulary than the scores of their peers in control group classrooms” (Trainin et al., 2016). This study further substantiated the support for the integration of literacy within content-area texts such as science and social studies. Positive results were evident for students in grades second through fifth and among different student groups, ELs included. This study, conducted by Trainin et al. (2016) strengthens the key idea that integration of literacy among the content areas reinforces reading development while increasing subject-area

comprehension. The measures included and the manner by which the authors demonstrate the measures were executed and reported increases the confidence in the results of this study and adds to the need of literature in regards to content-area instruction and literacy in elementary grades.

Vaughn et al., (2016), examined the efficacy of a conceptual understanding and reading comprehension intervention implemented among 18 eighth grade social studies classrooms in the article titled *Improving Content Knowledge and Comprehension for English Language Learners: Findings From a Randomized Control Trial*. This randomized control trial compared results from students in classrooms where the intervention took place and in the comparison classrooms where students were not served with the intervention (Vaughn et al., (2016). The comparison classrooms received what researchers referred to as business-as-usual (BAU) approach. The intervention, *Promoting Adolescents' Comprehension of Text* (PACT), provided an additional focus on academic vocabulary and peer interactions (discourse) and was utilized for 20 weeks regularly during their social studies time.

A closer look at the intervention shows that it was designed with five components which Vaughn et al. (2016) refers to as features of effective instructional practices for ELs. The first component is the Comprehension Canopy where, for 10-15 minutes, students engage in a purpose for reading which helps establish background knowledge on the topic. In this section, students also have time to engage in academic language through a canopy question that is assigned to each student (e.g. How did the colonial regions develop differently?) (Vaughn et al., 2016). The second component is the Essential Words piece that occurs after the Comprehension Canopy where teachers teach essential words to the content. During this time, students learn words through student-friendly definitions, visual representations, synonyms, examples and non-

examples, and are given a prompt by which students are required to discuss the words (Vaughn et al., 2016).

The third component is Knowledge Acquisition Through Text Reading. In this piece of the intervention, students would engage in reading a text multiple times. First, by reading it as a whole class with the teacher, then in pairs, small groups, and/ or independently. Additionally, the teacher was encouraged to review the essential word list and make connections within the context of the text to the words they had learned (Vaughn et al., 2016). During the TBL Comprehension Check, component four, teachers administered a short comprehension check twice every unit to examine students' conceptual understanding and vocabulary development. Each comprehension check had 10 comprehension questions and only five focused on vocabulary (Vaughn et al., 2016).

Students completed this comprehension check twice: once individually and a second time with a team. Using scratch-off cards, students responded and received immediate feedback on their answers. If, as a team, they responded incorrectly, then they could revisit their notes, texts, and discuss in order to select an alternative answer and support it with text evidence (Vaughn et al., 2016). The final component, TBL Knowledge Application, students were required to apply the knowledge they gathered from the unit and complete the assigned task, usually addressing a question that required problem-solving, sharing of ideas, extending their thinking, and mandated them to present their responses with evidence from the content learned (Vaughn et al., 2016).

All students were administered the Gates-MacGinitie Reading Comprehension Subtest which includes expository and narrative passages and multiple-choice questions related to each passage. With each passage and question, items increase in difficulty. Researchers also



developed ASK, a 42-item, multiple-choice, untimed test which looked to determine conceptual understanding of the three units studied in the intervention: Colonial America, Road to Revolution, and the American Revolution (Vaughn et al., 2016). The MASK measured reading comprehension, students' ability to identify the main ideas, comprehend vocabulary, identify cause and effect, and summarize texts through a 21 item, untimed multiple-choice test (Vaughn et al., 2016).

Results of various three-level regression models indicated that students who participated in the intervention, both ELs and non-ELs, outperformed those who were in BAU sections on conceptual knowledge acquisition and content-related reading comprehension. However, in the analysis of discourse, findings suggested that the influence of PACT may depend on the quality of classroom discourse. A major limitation of the study was the inability to have identified and tested the level of English language proficiency for each English learner. This is important to note because researchers were unable to address why the number of ELs in a classroom negatively affected the results of content knowledge on the ASK measure. This piece is critical to the instruction and success of ELs. Further research is needed to understand and examine the impact of discourse in the classroom.

### **Literacy-Infused, Inquiry-Based Science Instruction**

A small sample of studies and reports that the search revealed included researchers exploring the benefits of integrating English language development within the content areas such as science, social studies, and mathematics. As previously defined, content-area instruction is instruction of the disciplines: reading, writing, mathematics, science and social studies. While some studies were analyzed when other content areas were addressed, more attention was placed

to studies in which science was the context of instruction as it is the focus of this systematic literature review. Also, only a small number of studies indicated that they were conducted within an elementary context meaning grade levels kindergarten through fourth grade. Studies conducted in the middle school grades, that is to say fifth through eighth grade, were also considered in order to address the topic, literacy-infused, inquiry based science curriculum.

In *Attending to the Language and Literacy Needs of English Learners in Science*, Bravo & Cervetti (2014) examined the impact of integrating science-language curriculum within ten fourth and fifth grade classrooms in order to close the achievement gap between ELs and their native-English peers. Among the ten classrooms, 115 ELs were identified and 57 native English speakers. The quasi-experimental study findings showed promising results when optimizing instruction for ELs as they acquire content area knowledge. The treatment condition teachers taught 40-session experimental science and language integrated curriculum, while the control teachers taught a content-comparable curriculum focused on “hands-on” science (Bravo & Cervetti, 2014).

While the researchers mentioned that equal time was spent on vocabulary development in both control and treatment groups (e.g. there was no difference), classroom observations revealed that treatment classrooms had more teacher-student and student-student talk (Bravo & Cervetti, 2014). It is important to note this because it was possible that it impacted the post-test results. An analysis of variance was used to compare pre-tests and post-tests scores between comparison and treatment students and analysis indicated treatment students had significantly higher posttest scores for content knowledge and science vocabulary (Bravo & Cervetti, 2014).

While the intervention showed positive effects, the researchers were unable to measure if EL adaptations were made throughout both groups. The researchers had hypothesized that while

analyzing classroom observations, there would be an evidence of adaptations made (MA) to linguistically support ELs; regrettably, the calculated frequencies for MA were only 2; thus, researchers did not pursue additional analysis (Bravo & Cervetti, 2014). To be clear, the researchers did not state in their reporting of the results, what types of adaptations they were making observations for; thus, this would be a consideration for improvement on their next implementation of this particular study.

A pilot study conducted by Casey et al. (2018) in the elementary grades, focused on the area of interest, U.S.-Mexico border, the population of culturally and linguistically diverse (CLD) ELs, and how their use of Reciprocal Teaching (RT) could enhance their engagement and access to science content. In *Literacy & Arts Integration in Science: Engaging English Language Learners in a Lesson on Mixtures and Solutions*, the researchers explore Reciprocal Teaching. Through a Reciprocal Teaching (RT) approach, researchers sought to integrate a literacy & arts approach in the science content-area to provide students who struggle with vocabulary an opportunity to increase their comprehension of content. This strategy, RT, is important to note because aside from focusing on: (a) making predictions about the content-area text, (b) summarizing segments of the text, and (c) creating questions modeled after “teacher-like” questions, an integral part of RT involves clarifying unknown vocabulary words (Casey et al., 2018).

A major underlying theory for this study is the understanding that there is a need to focus on language through the use of culturally responsive pedagogy. Cummins (2008) argues that through culturally responsive pedagogy and an instructional learning environment that fosters language development, one could ensure students access vocabulary, language, and content simultaneously. Through RT, this study students had a chance to discuss science-specific

vocabulary and increase comprehension of expository texts (Casey et al., 2018). Although there are several limitations and variables that may have skewed the results in this study, it demonstrated how RT with embedded academic vocabulary development could enhance the teaching and learning among fifth grade students.

As a part of a greater study, this multi-component lesson provides students with strategies to enhance their understanding of content-area texts and increase academic vocabulary; however, this one lesson, as a “stand-alone” lesson should not be utilized to make generalizable results (Casey et al., 2018). In addition, the researchers did not take into consideration the covariate of pre-test results. This is crucial because the students were already grouped by ability, and student variability could have influenced the results of the study.

Another research project explored the idea that helping students acquire the academic language of science as well as the content can be daunting; however, if not done appropriately, educators run the risk of presenting science concepts using incomprehensible language (Brown & Ryoo, 2008). Brown & Ryoo (2008) presented an “aggregate” pedagogy by which a software, *The Directed Language Approach to Science Instruction* (D.D.A.S.I.), taught science concepts in everyday language first, then used scientific language to explain the concept. The control group followed this method. The treatment group; however, utilized a “disaggregated” approach where the science concepts were taught in everyday language and did not use scientific language until much later in the instructional process (Brown & Ryoo, 2008).

According to Brown & Ryoo (2008), both versions of the software, version 1 (simultaneous scientific language) and version 2 (delayed scientific language) include three phases: (1) Content Construction Phase, (2) Explicit Language Phase, and (3) Introduction of Explicit Language Phase. In the first phase, Content Construction Phase, the software teaches

the scientific concept in everyday language; however, in the treatment group, the scientific language is given at the time the concept is taught, while the control group is instructed with everyday language without introducing the scientific language at this stage.

The second phase, Explicit Language Phase, uses a variety of “interactive-drag-and drop-quizzes, language activities, animated instructions, and scaffolds students’ use of scientific language by introducing students to the specific language used to describe phenomena” (pg. 539). The difference between the two groups during this second phase is that the control group continues to use the scientific language throughout the entire instructional session, while the treatment group receives the scientific terms and the relationship between these terms and everyday language explicitly (Brown & Ryoo, 2008). The activities that follow within the Explicit Language Phase provide opportunities for students to use the language which in turn helps them comprehend the phenomena or science concept while acquiring the scientific terminology.

The third phase, Introduction of Explicit Language Phase, provides seven science experiments presented to both the control and treatment group in the same manner. There is no difference between groups in this phase. During this time, students receive instruction in scientific language to apply to the science concept and to teach scientific language. Throughout this instruction, students are required to solve problems and provide explanations of the concept.

The results from this study indicated that students in the treatment group, who were taught the “content-first” through everyday language, significantly improved their understanding of the concept when compared to the students in the control group who were taught in traditional ways (Brown & Ryoo, 2008). In the first analysis, students’ learning was evaluated by their performance on pre- and post-test measures, and the results of the t-tests on: (a) total

performance on question types, (b) performance on questions used to measure conceptual understanding utilizing everyday language, and (c) performance on questions used to measure conceptual understanding in scientific language.

Pre-test results indicated that students in both the treatment groups as well as the control groups attained similar scores on all three measures; thus, demonstrating that from a statistical perspective, there were no significant performance differences between groups prior to instruction (Brown & Ryoo, 2008). Post-test results showed that while both groups significantly increased in their conceptual understanding, the treatment group “showed greater learning gains across all measures when compared to the control group” (pg. 544). Specifically, in the area of scientific language attainment, it was clear that students who were taught science concepts and the meaning of the concepts in everyday terminology first, before exposing them to the specific, scientific terminology, benefitted most and made superior learning gains (Bown & Ryoo, 2008).

While this study by Brown & Ryoo (2008), examines the performance of students’ conceptual understanding and ability to comprehend and use scientific language through a “content-first” approach, in reality it is integrating language and content in its software; and moreover, demonstrates the need for teacher to place a higher importance on how to develop conceptual understanding while providing for students’ oral language development and academic language acquisition. It also must be restated that this approach was not explicitly utilized with second language learners or ELs; however, it is stated that 30 of the students’ first language was Spanish, which makes it possible that these students were or may have been ELs at one point.

In another study, (Conner et al., 2010) sought to develop a science curriculum that integrated science learning as well as literacy objectives to build both science conceptual understanding and literacy skills as well. However, they posed the argument that this type of

instructional approach should be utilized in the lower elementary grades because as students who start second grade with weak vocabulary, reading, and science conceptual knowledge, often do not make significant gains in terms of science achievement in later years (Conner et al., 2010). Because of this, Conner et al. (2010), created an entire unit of five lessons where five classrooms of eighty-seven second graders, in which student learning was assessed by pre- and post-test measures. Although the unit included opportunities for listening, speaking, reading, writing, and learning strategies, it was through writing that the researchers examined gains in basic literacy skills such as the number of sentences, the number of words spelled correctly, and the number of multisyllabic words (Conner et al., 2010).

When comparing students; pre- and post-test scores, results showed students increased their science content approximately 30% when implementing an integration of literacy-infused, inquiry-based science curriculum (Conner et al., 2010). In terms of the quality of students' written responses, results indicated confirmed that the grains in all five skills: (a) total number of words, (b) correctly spelled words, (c) ratio of correct to total words (%), (d) number of sentences, (e) number of multisyllabic words, were statistically significant in all areas.

This study, small in comparison, was powerful in that it showed how students who had begun the unit displaying weak science and literacy skills, but generally made gains in science conceptual understanding just as those students who had begun the unit with strong science and literacy skills (Conner et al., 2010). Again, this is important because based on this small study, it is possible that with the integration of literacy skills in the content-areas, specifically science, the achievement gap between student groups could be narrowed and ultimately closed (Conner et al., 2010). Although this study did not show that it was more effective than utilizing the traditional curriculum the school district provided, it opens the door for further administrators to hold

teachers accountable for an integration of literacy skills within the content-areas at a younger age rather than waiting until the upper elementary or middle, high school grades.

Cuevas et al. (2005) specifically examined the impact of an inquiry-based instructional intervention on students' ability to engage in science inquiry and skills therein. The participants, 25 third and fourth grade students from six different elementary schools including ELs in this study referred to as English for Speakers of Other Languages (ESOL) partook in an intervention that focused on two units for Grades 3 (Measurement and Matter) and Grades 4 (The Water Cycle and Weather) (Cuevas et al., 2005). These units were designed by science educators, scientists, and consultants, and were utilized by educators for approximately 2 to 3 months, and implemented in the classroom approximately 2 hours per week.

In this study, according to the National Research Council (2000), evidence that students are properly engaged in science inquiry occurs when students “generate questions, plan procedures, design and carry out investigations, analyze data, draw conclusions, and report findings” (Cuevas et al., 2005). Thus, the elicitation protocol structured the inquiry process for teachers and students who may have limited experience with science, and it is important to note that while many may argue that the inquiry process should not be structured in any way, the framework did include an open-endedness to allow for student initiative. It was also structured in a way to guide students through the inquiry process and gradually release the responsibility

Elicitation sessions were conducted pre- and post-intervention and a four-level scoring rubric assessed the conceptual accuracy and extensiveness of responses. Each elicitation sessions were 20 to 40 minutes long. Gain scores, using paired samples t tests were analyzed and indicated a statistically significant increase in students' ability to conduct scientific inquiry (Cuevas et al., 2005). Although the sample size was too small to analyze by subgroups,



specifically ELs, as a whole, demonstrated an increased effect size from 8.04 (SD=2.73) during pre-elicitations to 12.16 (SD=1.14) post-elicitations to conduct science inquiry. Students struggled to develop a problem statement and did not improve significantly from pre-intervention (1.40 (SD=.65) to post-intervention (1.72 (SD=.46)).

Results did indicate that students' ability to develop procedures for problem solving did improve significantly to 2.72 (SD= .46) from 1.36 (SD= .76). There was medium effect size when students were asked to generate a list of materials and how those materials would help to conduct their investigation (pre-intervention (1.16 (SD= .69)) to post-intervention (1.64 (SD= .57) (Cuevas et al., 2005)). In regards to students' ability to describe how the results of the problem should be recorded, student showed a statistically significant increase from the mean of .72 (S= .68) pre-intervention to 1.28 (SD= .54) (Cuevas et al., 2005). Ultimately, results indicated that there was a positive increase in students' ability to draw a conclusion from pre-elicitation .74 (SD= .86) to 2.00 (SD=.00). In looking specifically at ELs or ESOL students in regards to their ability to conduct inquiry, these students performed comparably to the non-ESOL students. The gain from pre-elicitation scores to post-elicitation for ESOL students was approximately 4.77 points and greater than the gain for non-ESOL students (3.42 points) (Cuevas et al., 2005).

The results gathered from this research are important to note as more emergent literature in science education sheds light on ELs and their ability to engage in science inquiry while developing the literacy skills to communicate their conceptual understanding. Further research is needed in order to truly examine how this intervention compares to a controlled setting utilizing district mandated curriculum documents; however, it is an example of how intentional learning

environments could be established to foster science inquiry as well as literacy in culturally and linguistically diverse classrooms.

Amaral et al. (2002) also found an importance in helping ELs to increase achievement through inquiry-based science instruction. In this study, conducted in a California school district, the percentage of ELs (53.9%) was double than the percentage of ELs in the entire state (24.9%) (Amaral et al., 2002). When Proposition 227 passed in 1998, teachers and students were required to adhere strictly to the language set by the law and began to turn to the content-area subjects, such as mathematics and science, to help ELs improve their conceptual understanding while furthering their English literacy skills (Amaral et al., 2002).

The intervention used in this study included four instructional units per year (kindergarten students were only exposed to three) where teachers taught approximately eight weeks utilizing (1) *Science and Technology for Children* (STC) developed by the National Science Resource Center, (2) *Full Option Science System* (FOSS) developed by Lawrence Hall of Science, University of California, Berkeley; and (3) *Insights* created by the Education Development Center in Newton, Massachusetts (Amaral et al., 2002). Although this intervention was done from kindergarten to grade 6, for the purposes of this review of literature, we will only be looking at grades 5 and below.

Data gathered from the 4-year study indicated that there was a distinct difference among those students who participated in the curriculum mandated by the school district verses those who received the literacy-infused, inquiry-based science intervention. According to Amaral et al., (2002), a linear regression analysis established a positive correlation and a breakdown of student conceptual knowledge measured by the Stanford Achievement Test and students with different levels of English proficiency. Students who were identified as ELs (Limited English

Proficient (LEP)) in the fourth grade participating in the intervention showed growth and improvements the longer they were exposed to the intervention as opposed to those who had not participated or participated for a shorter period of time (Amaral et al., 2002).

In summation, from the results in this study, an integration of science and language learning is a possible approach educators can utilize to enhance the overall conceptual knowledge and literacy skills of ELs (Amaral et al., 2002). Through the use of inquiry-based materials, building common experiences, utilizing thinking skills through cooperative learning, and creating a learning environment with comfortable and positive attitudes, students can be encouraged to peak further interest in inquiry-based science and increase their English language development simultaneously. While this study contributed to the literature of inquiry-based science writing achievement in ELs, no writing rubric was included as an example to view how writing achievement was analyzed.

Adding to the literature of integrating literacy and science for English learners, Tong et al.'s 2014 article, *Integrating Literacy and Science for English Language Learners: From Learning to Read to Reading to Learn*, discussed the impact of 2 longitudinal interventions for 56 English learners. Fifth graders received science instruction with language/reading embedded in their daily schedules, and while in grades kinder through third grade had received English language/reading with a specialized science focus (Tong et al., 2014). This study is significant in that it contributes to the literature intended to highlight interventions which may benefit ELs and former ELs in acquiring academic language as well as learning English as a second language. Important in this study is the longitudinal analysis that examines the participant's academic development from early elementary grades to middle school level which is where the academic achievement gap widens and most often is never closed (Tong et al., 2014).

In this study, the 23-week science intervention included two components: professional development provided to content area teachers and academic science interventions implemented with students 85 minutes daily utilizing the 5-E model. In the first component, teachers received ongoing, systematic and structured training, including “monitoring, mentoring, feedback, and self-assessment through reflection via professional portfolio” (Tong et al, 2014, p. 416). Training also included a preview prior to implementation of the intervention aimed at enhancing teachers’ knowledge of content area literacy including (a) fluency in English science vocabulary, (b) English development in oral and written science literacy, (c) reading comprehension in the science content, (d) the utilizing of ESL strategies, and (e) the implementation of science teaching employing the 5-E model.

The second component, academic science intervention, infused reading and writing activities into the instruction through the five stages of the 5-E model (i.e., Engage, Explore, Explain, Elaborate, and Evaluate). Students were engaged with an informational text, science focused, equipped with vocabulary development, extensions, word-reading instruction, and opportunities for partner reading. Through the use of science notebooks, students recorded key vocabulary terms, processed science content, incorporated study guides, recorded predictions and observations, completed foldables, and responded in writing from multiple perspectives in forms of postcards and newspaper articles.

Student performance was measured using both standardized tests and district developed benchmark test in the areas of science and English language and literacy. Results indicated that a difference existed between the treatment and control groups in the science intervention, with 100% students in the treatment group meeting the passing standard on the benchmark science test as opposed to 76% passing by those students participating in the business as usual (BAU)

science instruction. Furthermore, a chi-square test revealed a marginally significant result on the rate of commended performance among those in the treatment group (66.7%) as compared to the control group (30%).

On the state science, standardized test (Texas Assessment of Knowledge and Skills (TAKS)), no statistically significant differences were noted between the treatment and control groups; however, an average of 93.3% students passed with a 36.7% receiving commended performance. On the state reading standardized test (TAKS), the chi-square test did yield a significant result on the rate of commended performance, with the difference between students in the science treatment (35.7%) and control (7.7%) participants who did not receive the intervention.

In terms of English oracy and literacy as measured by the Dynamic Indicators of Basic Literacy Skills (DIBLES), the ANOVA revealed a statistically significant main effect of time suggesting a significant improvement from pretest to posttest across gender and condition. Additionally, when excluding gender in the analysis, students in the science treatment group outperformed their peers in the control group. According to the Woodcock Language Proficiency Battery-Revised (WLPB-R), a repeated measure analysis indicated a statistically significant effect of time on all three subtests; thus, suggesting a substantial improvement across gender and condition from pretest to posttest. Specifically, between gender and science condition, the effect was also significant on all two subtests. Particularly, the two-way within-participant interaction effects were significant between time and science intervention on oral vocabulary and amid time and literacy intervention on all three subtests; students in the treatment condition achieved higher gains from pretests to posttests.

Overall, this study provided integral evidence on the relationship between learning to read and reading to learn in science. Results suggested that those students received literacy-embedded science instructional intervention in fifth grade outperformed those who did not, specifically in the areas of English oral reading fluency, understanding word knowledge, mastery of grade level science concepts and high-achieving performance in science and reading on state standards. Furthermore, those students who had participated in the science-embedded English language intervention in grades kinder through third, continued to develop faster in the areas of oral reading fluency and closed the achievement gap between their monolingual native English peers at times approaching or outscoring them by the grade-based standard scores.

Results from students' knowledge of science concepts, performance on state mandated reading assessments, and comprehension skills further indicated that those students who received literacy-embedded science intervention during fifth grade as well as had participated in the reading literacy intervention continuously from kinder through third grade benefitted immensely. It should be noted that ELs who did not participate in either intervention received the lowest performing scores in science, reading, and English language development.

While the sample size of this study was small, its findings should be considered as significant due to the quality of strategic statistical data that was used to analyze results from this study. Although sample size is a limitation and all EL participants were from the Hispanic minority group, the outcomes are noteworthy as they shed light on the benefits content area literacy instruction could have on second language learners in the area of science. Additionally, this longitudinal study draws attention of the need for instruction to embed reading skills within the science content; learning to read within authentic context, such as science is crucial to the development of multi-literacies in the English language.

Another perspective, yet crucial to the development of academic language and conceptual understanding, is Huerta et al.'s (2014) development and validation of a science notebook rubric for populations of Hispanic ELs and other minorities. This study was a part of a larger study, Project Middle School Science for English Language Learners (MSSELL). Its impact on the future science classrooms and the need for embedded literacy instruction which shows is an effective component for the development of conceptual understanding (Huerta et al., 2014). Huerta et al. adds to the much-needed research gap on instruments or rubrics used to measure non-mainstream students' writing. The rubric developed by Huerta et al. is important in the focus of ELs as it was centered on second-language acquisition theories as well as theories of writing and conceptual understanding.

A major focus of the rubric is the development of academic language, specifically the difference between BICS and CALP. Huerta et al. also addresses the need to focus within the academic language umbrella on the difference between scientific language and everyday language. This is crucial to note as scientific language includes specialized, technical vocabulary and discourse patterns which may or may not hinder conceptual understanding (Huerta et al., 2014). In the study, Huerta et al. argues that ELs must learn the "distinctive features of scientific language in order to succeed academically in the science classroom" (Huerta et al., 2014, p. 5) If ELs, whose first language is not English, must acquire the particular English scientific language in order to engage in scientific discourse, then it does not become a wonder why ELs are not choosing careers in the STEM areas.

Specifically, Huerta et al. (2014) addresses, the acquisition of science concepts, conceptual understanding through the writing process as the indication of concept attainment. Writing, or science note-booking, then proves to be a tool by which ELs could actively construct,

alter, and revise their conceptual understanding utilizing the appropriate academic language to then develop scientific literacy. Within this literacy intervention, Huerta et al., (2014) analyzed science writing artifacts which may or may not have included illustrations or drawings; thus, clarifying that writing is considered any artifact that can be analyzed and quantified in a meaningful way (Huerta et al., 2014, Ruiz-Primo et al., 2004).

The larger study (MSSELL) included science inquiry and literacy integration and as an integral piece of the enhanced science instruction, students were required to keep science notebooks. Huerta et al. (2014) selected only students who participated in the first year of the MSSELL project for sampling purpose (N=210), and collected 30 notebooks, 20 from ELs, 10 from Native English speakers. Based on an instrument developed by Ruiz-Primo et al.'s (2004) study, Huerta et al. (2014) developed a science notebook rubric with close attention paid to minorities, socioeconomic status, gender, and language status.

Academic language was quantified by creating a separate scoring criteria dependent on the written task that was required on the day of the notebook entry. Five tasks were identified based on the initial sample which was used to train and calibrate raters (Huerta et al., 2014). These tasks were: “(a) defining; (b) illustrating and labeling diagrams; (c) organizing information using two-dimensional figures (i.e. charts, tables, graphs, and schematics); (d) recording observations and prediction; and (e) reflecting” (Huerta et al., 2014, p. 8). In addition to the expectation of rigor in the quality of communication through note booking, Huerta et al.'s rubric not only accounted for the academic language of science, but also the mechanics required in the English language for clear communication such as, punctuation, spelling, and grammar. The rubric developed by Huerta et al. included criteria to measure these English conventions as adapted from portions of the Texas English Language Proficiency Assessment System



(TELPAS) –a state assessment required by the federal government to assess the English language proficiency of all ELs.

In terms of quantifying conceptual understanding, Huerta et al. (2014) expected that each of the entries include a response fitting to address the objective aligned to the state standard for each science domain. Descriptions provided in the rubric delineated the levels of understanding which helped to rate each entry taking into account the visual entries (e.g. diagrams, tables, illustrations). Expectations for visual entries were stated, acknowledge, and required that labels were correctly written, relationships between visuals and written language clearly expressed and cohesive, as well as the purpose for the illustration explained (Huerta et al., 2014).

Huerta et al.'s (2014) study continues to be unique and pertinent in its contribution as it further addresses content validity. Four expert reviewers were sought out to review the rubric and provide feedback to ensure the instrument addressed and measured accurately students' academic language and conceptual understanding. After feedback from the four different reviewers were gathered and explored, the rubric was refined and updated to address different specifics: (a) providing specific examples within the rubric, (b) adding bullet points to make the explanatory language on the rubric easier to understand, (c) creating a manual for raters of the rubric to follow and refer to when needed, (d) combining the language and concept rubric to one document rather than having two separate pages (Huerta, et. al, 2014).

Scoring the rubrics for each domain (i.e. Domain 1: Physical Science; Domain 2: Earth/Space Science; and Domain 3: Life Science) involved first assuming that language and concept scores should be related (Huerta et al., 2014). Language and concept scores were correlated as a proxy measure of validity and averaged using three raters across the three domains and two constructs (language and concept). Scores were then compared by categories

(n=8). The study included samples of a notebook page and the process by which validity was established using the rubric. Generalizability theory (G theory) was used to determine reliability. This method uses an analysis of variance to estimate the variability as a result of sources of error past the measurements over a period of time (Huerta et al., 2014).

Results from both the validation and reliability studies demonstrated that correlations between language and concept scores were positive and large. More specifically, the results indicated that the mean language score for native English-speaking students (.41 points) was higher than the mean language score for ELs. Likewise, the concept score for native English-speaking students (.48 points) was higher than the mean concept score for ELs. Inter-rater reliability using G theory indicated that the generalizability coefficient in regards to the language rubric was 0.71, relative error of 0.032, and in regards to the concept rubric was 0.61, relative error 0.047; however, these coefficients were lower than the rubric by Ruiz-Primo et al (2004). Additionally, the percent agreement was higher for language and concept parts of the rubric (0.93). Huerta et al (2014) also examined the results from the D-study in regards to the efficiency in rating and reliability and took into account various ways the instrument could be modified to increase the reliability coefficient.

Above all, Huerta et al. (2014) study provided a systematic process by which a rubric was developed and validated to measure both academic language and conceptual understanding for non-mainstream, low-socioeconomic, and/or Hispanic ELs. This rubric will most likely serve to provide insight into the much-needed research on ELs and their development of English language proficiency, academic language, scientific language, as well as science concept attainment. While the study used a small sample to test the rubric, the development in this area of interest utilizing Huerta et al.'s (2014) instrument is promising.

In Lara-Alecio et al.'s (2018), the researchers also explored the effects of implementing a literacy-infused, inquiry-based curriculum; however, they focused on middle school Spanish-speaking ELs and economically-challenged (EC) students. This study, as a part of a randomized control trial (RCT) longitudinal evaluation, paid close attention to the teaching and learning of academic language, science content and literacy, as well as oral language development skills (Lara-Alecio et al., 2018). A total of 276 sixth-grade students (160 ELs) participated in this study where an analysis of covariance (ANCOVA) was executed with "pre-test as the covariate and the post-test as the outcome variable" to view student progress data and compare treatment and control groups (Lara-Alecio et al., 2018). A Pearson's  $r$  correlation analysis was also conducted to closely assess the association between students' English language proficiency and science content knowledge.

Analysis and results suggest that ELs who participated in the treatment group outperformed the control group in the post-test after adjusting for pre-test performance on an assessment designed to measure science understanding or the Big Idea aligned to the Next Generation Science Standards. In addition to this, the correlation analysis results disclosed that there was a statistically significant and positive association between the students' scores on the science content assessment and the oral language proficiency exam. That is to say the literacy-infused, inquiry-based science curriculum implemented in this study provided reason to believe that ELs increased their vocabulary and oral language expression all while content knowledge was achieved (Lara-Alecio, 2018). Although this study placed importance on students making scientific connections of concepts and technology was infused in the lessons, it is still important to include in this systematic literature review due to the statistically significant results in the areas of content knowledge, vocabulary and oral language expression.

In 2014, Tong et al. (2014), also presented findings from a randomized control trial study of literacy-integrated science inquiry intervention which consisted of: “(a) an ongoing professional development, (b) specific instructional science lessons which were inquiry-based, (c) direct and explicit vocabulary instruction, and (d) an integration of reading and writing” (pg. 2083). This intervention was based on the idea that scientific language is a type of English language that, while integral to the learning of science, is often lacking in the middle and high school classrooms due to the lack of knowledge educators have as to how to integrate literacy instruction into hands-on science inquiry (Tong et al., 2014).

In this study, Tong et al. (2014), collected data from 94 low socio-economic status non ELs who participated in structured, literacy-infused, inquiry-based science lessons for 85 minutes a day. Major components of the intervention included *Daily Oral and Written Language in Science* (DOWLS) activities which prompted students with science-related situations and asked the students to think, record their written responses and discuss their responses with a partner. Another major component was Content Area Reading in Science for English Literacy and Language Acquisition (CRISELLA). In CRISELLA, the goal was to provide activities for vocabulary development and further explore concepts in science-related expository texts (Tong et al., 2014).

In order to evaluate the effectiveness of this literacy-integrated science intervention, researchers utilized state-standardized and district benchmark tests in the areas of reading and science, as well as the Dynamic Indicators of Basic Literacy Skills (DIBELS) to measure early literacy skills. Descriptive statistics analyzing benchmark scores showed that students in the treatment groups were more likely to pass than were the control students when taking the same test (Tong et al., 2014). When looking at treatment-gender-ethnicity differences, statistics

indicated that Hispanic males in the treatment group had the “highest change of achieving mastery level” (pg. 2099).

A multilevel logistic analysis was conducted to analyze how students’ performance differed on the state-standardized assessment, science TAKS test after participating in the literacy-infused, inquiry based science curriculum. Results indicated that treatment students were 2.80 times more likely to pass the science TAKS in comparison to their control peers; however, this result was considered statistically non-significant (Tong et al., 2014). In terms of reading achievement, when observing data collected from reading benchmark tests, it is important to note that while Tests 2 and 4 indicate significant difference in the rate of passing; however, the result was not statistically significant if using the standard significance level of 0.05.

In addition to the reading benchmark tests, results indicated that the ethnicity coefficient was statistically significant. The rate of passing for Hispanic students was higher than the rate of passing for African-American students, but no other fixed effects were identified to be statistically significant. Also, in terms of oral reading fluency, the multilevel analysis demonstrated that Hispanic male students in the treatment groups scored 7.85 points higher than their control peers.

Ultimately, the results from this study could help us conclude that students in the treatment group did demonstrate a satisfactory performance and gained more understanding of the different science topics in comparison to the students in the control group. In the area of reading achievement, students in the treatment groups also achieved faster in oral reading fluency. Because this study addressed the lack of knowledge by middle and high school

educators to successfully integrate literacy in an inquiry-based science curriculum, findings will have a direct impact on the aforementioned need.

In 2012, Taboada et al. focused on integrating literacy in a science curriculum and researched the impact of questioning on general vocabulary and science reading comprehension. This study is important because it places emphasis on utilizing the content-area, science, in order to build content knowledge, vocabulary, and ultimately, English language proficiency. The overall research was divided into two studies. Study 1 general vocabulary was observed and measured. In the first study, two fifth grade classrooms in a school located in a large suburban mid-Atlantic district, sixty fifth grade students, 25 ELs ranging from intermediate to advance levels of proficiency were administered the Woodcock-Muñoz Language Survey-Revised Battery (*Woodcock-Muñoz-Sandoval, Ruef, & Alvarado, 2005*) to assess students' general vocabulary using the Picture Vocabulary subtest. The subtest is considered as a measure of common vocabulary to indicate general English language proficiency (Taboada et al., 2012). Strictly speaking, vocabulary which can be utilized across the content areas, in contrast to those terms which are content-specific.

In this first study, results indicated significant implications in the area of general vocabulary as a strong predictor of content area reading comprehension. This is an impertinent result because it revealed that vocabulary had a greater impact in the attainment of conceptual knowledge than EL students' text-based questioning strategy, the main focus of the study. It is not to say that student text-based questioning is not important in the development of content knowledge; however, in terms of native-English speakers, text-based questioning was a stronger predictor of comprehension.

Findings in Study II demonstrated that when integrating language and content in a fourth-grade classroom of ELs whose English proficiency was between low-intermediate to advanced levels of proficiency (Taboada et al., 2012). While the focus of this study was on building science content through questioning, one of the characteristics of the literacy-infused, inquiry-based science curriculum was that close attention was paid to teaching content-specific vocabulary terms within the questioning strategy (Taboada et al., 2012). As students were sharing their self-generated questions, science vocabulary terms were discussed which were essential to the topic, concept, and overall, comprehension of the science content.

The Woodcock Diagnostic Reading Battery (WJIII) (Woodcock, Mather, & Shrank, 2004) was utilized in Study II to measure students word decoding, reading comprehension, and general vocabulary. The subtests, Letter-Word Identification, Passage Comprehension, and Reading Vocabulary helped to establish that concept attainment or content knowledge for ELs is more dependent on vocabulary knowledge than text-based questioning. While questioning could be a beneficial tool for the development of ELs content knowledge and comprehension, a foundation of vocabulary knowledge should be established in order to ELs to make connections throughout the content or across content areas (Taboada et al., 2012).

Ultimately, it is important to note the Taboada et al. (2012) study expresses that literacy instruction is not always integrated within the content-area; however, teaching a content-area and the academic language required to the EL population is a pressing issue; an issue that is often regarded as a middle- or high-school concern. However, placing an emphasis on the early elementary grades to incorporate literacy skills within the content areas could possibly influence the long-term achievement of ELs (Taboada et al., 2012).

## Gender Differences in the STEM Classroom

According to Scantlebury (1994), most cultures provide females and males with different social experiences so that by the time both begin formal schooling they begin with different understandings, prospects, and assertiveness in learning. Moreover, researchers have confirmed that these gender stereotypes persisted in science learning beginning as early as first grade and into the secondary grade levels (Scantlebury, 1994). Other studies conducted utilizing data from The Nation's Report Card: Science 2005 have indicated that in the area of science, males continue to score higher than females (Grigg, Lauko, & Brockway, 2006). A longitudinal study from 1969 to 1999 found that when examining NAEP data, males in the elementary and middle schools also outperformed females on science achievement exams (Campbell, Hombo, and Mazzeo, 2000).

While many can agree that there exist gender disparities in the STEM careers, most research has focused much of its energy in the secondary grade levels or postsecondary students, which at times may be too late to target, engage, and grow young scientists or mathematicians (Curran & Kellogg, 2016). Furthermore, recent evidence found that early science achievement is vastly foretelling of science achievement in subsequent academic school years (Morgan et al., 2016). Still, the literature regarding science and the gaps therein are far sparser when looking at elementary years of schooling (Curran & Kellogg, 2016).

In Curran & Kellogg's article, *Understanding Science Achievement Gaps by Race/Ethnicity and Gender in Kindergarten and First Grade*, the researchers stressed the importance of looking at science achievement at the primary grades as a way to understand science achievement gaps. They utilized nationally representative data from Early Childhood Longitudinal Study, Kindergarten Class of 2010-2011 (ECLS-K:2011) and a least squares



regression model to predict standardized science achievement from gender. Initial results indicated significant science achievement gaps in these first two years of primary schooling due to factors of race/ethnicity, social economic status, and gender. Particularly, for the female-male gap, in Kindergarten no gap in achievement was significant; however, it grows by the end of first grade ( $\beta = -.062, p < .01$ ).

Many studies have provide conclusions regarding the gender disparities in science achievement in the secondary and post-secondary classrooms; however, the findings from this article are powerful in that it demonstrates that the gender disparity in STEM related fields may be fostered in the earliest grades of school. This is necessary to take into account because the achievement gap, while small, could affect the trajectories that result in larger science achievement gaps between genders in later educational settings and in the workforce.

Due to the high-stakes requirements added with the enactment of NCLB in 2001, science teaching was reduced to make time for the tested subjects: reading and math; however, in 2007, national science testing became a requirement, and now science achievement data can be analyzed. Hence, in a nationwide study by Kohlhaas et al. (2010), researchers were able to examined the relationship among gender, and other factors such as ethnicity and poverty with fifth graders' science performance.

Using the Early Childhood Longitudinal Study, Kindergarten Class of 1998-99 (ECLS-K) initiated by the U.S. Department of Education, researchers used data involving 8,741 fifth grade students, 48% males and 52% females with an ethnic distribution of 58% White, 19% Hispanic, 11% African American, 7% Asian, and 6% other (Kohlhaas et al., 2010). Through a full 3-way analysis of variance (ANOVA) model statistics was used to test the main effects and the results of the interactions between gender and ethnicity (2 x 5) indicated that the mean scores

for males in the all the ethnic subgroups were higher than females. The interaction between gender and ethnicity was statistically significant. This is consistent with much of the research that confirms males perform better than females in the area of science. Males had a mean score of 59 with a standard deviation of 14.33, while females had a lower mean score of 56 with a standard deviation of 14.26.

This study made a case for improving school success by noting the achievement gap between subgroups: gender, ethnicity, and poverty. Looking particularly at gender, there is a strong need to address gender issues and biases in the classroom in order to create a culture where gender differences can be minimized and dissipated. Moreover, future studies are needed to include English learners in the subgroup category in order to begin disaggregating the data. With specific subgroup information, stakeholders can make better decisions and actions to close these gaps (Lynch, 2000).

In another study, conducted by Mendez et al. (2018), researchers sought out to use a randomized pre-and post-test group design to explore the outcome of utilizing culturally and linguistically responsive pedagogy (CLR) among Latino preschoolers and its effects related to gender. Researcher's note that this an individual variability which may affect vocabulary acquisition in both L1 and L2. Because these students are in their early stages of language development, they often adapt the language of their caregiver and the worldviews therein (Mendez et al., 2018). The differences in language development by gender may be because Latino girls may spend more time at home with their mothers using their native language, whereas Latino boys may spend more time outside the home and immerse with the mainstream language.

Mendez et al. (2018) used a sample of preschool children (N=77; 28 girls, 49 boys) enrolled in two Head Start programs in Carolina. Due to utilizing a complete randomized study, the only differences between treatment and control were the participants. After utilizing the multicomponent intervention which encompassed shared reading and exposure to specialized vocabulary instruction, the results showed that after adjusting for the means, students in the CLR group scored higher than those students who were in the English-only group (Mendez et al., 2018). On average, students in the CLR group learned 5.72 English words in comparison to the control group which averaged 2.77 words by the end of the intervention (Mendez et al., 2018).

In analyzing the effects of this heightened bilingual vocabulary intervention on gender, the statistical analysis revealed that regardless of gender, and initial vocabulary levels, bilingual children benefit from approaches which further attests the need to support instruction or interventions which heighten language development through multicomponent of balanced literacy such as shared reading, partner reading, vocabulary instruction, and other integrated evidence-based strategies (Mendez et al., 2018). While this study is powerful in its contribution to the literature, a larger sample is needed to increase the statistical power in detecting small effects from interactions between gender, language baselines, and the treatment effects.

There continues to be scarce research available involving gender differences in science achievement in the elementary grades for ELs; thus, the need for such studies is sizable. Bacharach et al., (2003) notes that as is the case with racial achievement gaps in science, the gender achievement gap exists and is notable during the primary grades, and data suggests that it continues to persist through secondary school. Using nationally represented data, Bacharach et al. (2003) analyzed the science achievement of 668 Black children and 5,463 white children (52% of the black children were girls, and 51% of the white children were girls).

The primary purpose of this study was to examine the factors and the changes therein of the academic achievement gap between students according to race and gender as they progressed through secondary grades (Bacharach et al., 2003). Using a hierarchical linear model to study the main effects of race and gender on science achievement, Bacharach et al. (2003) found that 8<sup>th</sup> grade science achievement scores differed significantly between males and females. Additionally, the average yearly gain in scores for males was larger than the average yearly increase for girls.

Sadly, the academic achievement gap is not minimized, rather continues to increase throughout high school grades. Regrettably, while students continue to attend schooling, in this study, secondary education does not aid in closing the science achievement gap associated with gender. While this study did suffer some attrition, which is to be expected, the sample size was sufficient enough to provide influential data representative of the nation's issues in science achievement.

### **Student Discourse in Science Classrooms**

Researcher Shu-Wen Lan (2013) explored the issue of boosting the role of classroom talk in science classroom for the purposes of increasing the success of ELs as they accomplish science tasks and attain scientific literacy. Many content-area teachers use academic discourse themselves; however, seldom provide opportunities for students to utilize academic language through discourse themselves (Lan & de Oliveira, 2019). Lan argued that while reading and writing about science topics is highly important and ultimately necessary, classroom interactions and the need for classroom talk must be nurtured in order to scaffold towards reaching subsequent scientific literacy in writing and reading domains (Lan, 2013). With the new K-12

science standards, Next Generation Science Standards (NGSS) of 2013, the need for science teachers to encourage ELs' communication within the classroom has increased; however, there has been little to no research that addresses the need of classroom discourse for the development of ELs' academic language in the elementary science classroom setting.

In a study by Garza et al. (2018), instructional practices centered around language, specifically academic language using the observational tool, Transitional Bilingual Observation Protocol (TBOP), the researchers sought to find out if there were statistically significant differences between treatment and control groups when students and teachers used academic languages. Furthermore, this study investigated what instructional practices displayed more frequently in each group.

The TBOP domains specifically addressed in this study were: (a) activity structures: the kind of activity that was occurring in the classroom; (b) communication mode: any listening, speaking, reading, and writing or the absence of these taking place in the classroom; (c) language content: type of language used in the classroom (e.g. light cognitive vs. dense cognitive language); and (d) language of instruction: whether students' native language was used as a support for the acquisition of students' second language (Garza et al., 2018).

Results in this study indicated that while both treatment and control classrooms used academic language during the course of the intervention, ELs in the treatment classrooms had more opportunities to use academic language than in those EL participants in the control classrooms (Garza et al., 2018). Additionally, the ELs in the treatment group participated in more activities in the classrooms that were coupled with reading and writing opportunities versus in the control group where there was more evidence of the teacher speaking and students

listening. This study provided valuable data to shine more light on the benefits of utilizing classroom “student-talk” and “teacher-to-student interactions” to develop academic language.

In a study by Jacoby and Lesaux (2014) addressed the support for the use of extended discourse in a large head start organization that served a large number of Latino children, and while most national data may not be available and examined until grade 4, evidence from research contends that the early language experiences and instruction have an effect beginning as early as preschool years. Additionally, Snow, Tabors, and Dickinson (2001) define extended discourse, a term for talk between adult caregivers and children, an opportunity for children to build a linguistic structure and communicate ideas. In fact, evidence suggests that a teacher who uses significant extended discourse could “influence children’s receptive vocabulary and emergent literacy skills” (Jacoby and Lesaux, 2014).

The participants in this study were chosen because they were enrolled in a Spanish-English bilingual Head Start program. There were six targeted preschool classrooms observed and the children ranged from 2 years, 9 months to 6 years (Jacoby and Lesaux, 2014). Three of the teachers involved in the project were English speakers who self-identified as White, while the other three teachers were native Spanish speakers who self-identified as Hispanic. Using the Observation Measure of Language and Literacy Instruction (OMLIT; Goodson, Layzer, and Smith, 2006) tool, researchers collected data on the quality and quality of language used during instructional activities such as whole-group, small-group, and one-on-one interactions between teachers and the students.

After observing approximately 147 lessons throughout the six classrooms, the observations from the OMLIT indicated that the use of English predominated and Spanish was used more frequently for non-instructional purposes than as a means of developing children’s

language and literacy knowledge (Jacoby and Lesaux, 2014). In regards to extended discourse, the majority of the classrooms did not foster opportunities for extended discourse. This study indicated the portrayal of the language environment that lacks in frequent, quality teacher-child interactions to support literacy development (Jacoby and Lesaux, 2014).

The implications of this study are that while teachers may want to extend conversations between themselves and students, teachers have not had the training or professional development to understand how to structure learning experiences to foster extended discourse. This raises a lot of questions and moreover the need to shed light on the dire characteristics of language learning environments that serve large numbers of Latino children (Jacoby and Lesaux, 2014).

More studies confirm the awful truth that most often, our ELs are exposed to lecture models of English educators who do all the talking and rarely generate dialogue to discuss, engage, or discover new knowledge (Rodriguez-Valls, 2009). Moreover, discussions often fail to give students a chance to express their own ideas and hear others' ideas (Chinn, et al., 2001). Researchers, Varelas, Pappas, and Rife, in *Establishing Scientific Classroom Discourse Communities: Multiple Voices of Teaching and Learning Research* explore a second-grade classroom in an urban elementary school with a diverse student population (African American, Latino/a, and Anglo) (Varelas, Pappas, and Rife, 2005). Throughout the year, the qualitative research and analysis sought to examine various types of data: audio- and video-tapes of lessons, whole-class debriefings, classroom field notes, etc.

From the discourse analysis, researchers documented students and teachers engaging in classroom talk regarding scientific ideas. Through this classroom discourse, scientific literacy was evidently emerging as students and teachers engaged co-constructed science understandings through collaboration and scientific talk (Varelas, Pappas, and Rife, 2005). Additionally,

researchers highlighted the variety of registers that were used and created in order to build knowledge and explain scientific concepts (Varelas Pappas, and Rife, 2005). Through the discourse analysis, researchers noted how the teacher fosters classroom talk; yet, also encouraged technical registers when probing further discussions from other students.

From this second-grade classroom, dialogic inquiry provided a means to create interactions and revise interactions to formulate scientific literacy. While the teacher was a frequent contributor to the classroom discourse, the researchers noted that the discussions she partook in were not a simple “initiate, response, and evaluate” formula which by most teachers seem to employ (Varelas, Pappas, and Rife, 2005). One of the major findings of the analysis was the recognition of students as active participants in their learning who not only share important ideas of their lives; rather that as the children make connections to scientific information, they begin to develop scientific literacy and understanding (Varelas, Pappas, and Rife, 2005). Many researchers concur with the need for students to use the scientific literacy as a means to think, know, and share not simple as a way to regurgitate factual information; thus, the need for students to engage in scientific discourse (Rosebery et al., 1992).

### **Summary**

By no means can educators, legislatures, and politicians continue to ignore the ever-growing EL population and its poor achievement in the content areas such as mathematics, science, and social studies; however, if the country truly has the interest of its people in mind, then this systematic literature review sheds light on instructional approaches in which not only the achievement gap can be narrowed and closed, but ELs could attain the English literacy skills to undertake careers in the STEM areas.



The findings from this literature synthesis validate several conclusions regarding literacy-infused, inquiry-based science curriculums and ELs. First is that when educators successfully integrate literacy, opportunities for listening, speaking, reading, and writing, into their content-area, specifically science, ELs could improve their academic language (Trainin et al.2016). Secondly, literature supports that the development of scientific literacy for ELs should come with intentional and purposeful lesson planning and attention to conceptual understanding in comprehensible language (Brown & Ryoo, 2008).

Thirdly, literature supports that teachers seek ways to incorporate inquiry-based, science methods which exercise the thought processes of ELs in ways that literacy skills can be practiced and gained (Cuevas et al., 2005,). All this to ultimately gradually increase the student achievement for ELs and help them attain conceptual knowledge in the content areas (Conner et al., 2010).

## **CHAPTER III**

### **METHODOLOGY**

The purpose of my study was to examine the impact of a literacy-infused, inquiry-based science intervention and ELs' expressive oral language and English vocabulary development on pre-and post-assessments, with a focus on a Texas-Mexico border school district. This study aimed to (a) investigate to what extent was there a difference between English oral language expressive skills of ELs across groups and genders (b) compare the extent of the differences between English picture vocabulary skills of ELs across groups and genders, and (c) examine if a difference exists between classrooms utilizing the literacy-infused, inquiry-based science curriculum and those who are not, in relation to "student-talk" and/or "teacher-to-student interactions" in either English or Spanish academic language?

This chapter describes the methodological design of the larger study from which the present study was formed. The chapter includes sampling, context of the study, intervention, instrumentation, data collection, data analysis, and a summary.

#### **Research Design and Sampling**

The present study is a part of a larger study, English Language and Literacy Acquisition Validation: ELLA-V, specifically Content Reading Integrating Science for English Language and Literacy Acquisition (CRISELLA) (PR/Award Number U411B120047), one of two treatments that were conducted. This federally funded project targeted approximately 150 third grade classrooms (T and C) and the impact of the intervention on ELs' expressive oral language, reading, writing, and science achievement. The hypothesis of the larger study was to

demonstrate that a literacy-infused, inquiry-based science intervention through content reading integration would improve EL's expressive oral language, vocabulary development, and science achievement.

The larger study conducted a randomly controlled trial design using schools as the unit of analysis. A Randomized Control Trial (RCT) design was used to reduce bias, establish a controlled experiment, and create an efficient statistical analysis. All randomly assigned schools were identified as serving native Spanish-speaking ELs in urban, suburban, small town, and rural districts. The schools identified as the treatment condition received a content area reading intervention integrated with science and those schools in the control group received typical instruction. The investigators conducted pre- and posttests to participants in both treatment and control classes utilizing the Woodcock Muñoz Language Survey– Revised.

For the purposes of this present study, archived data from one urban school district located on the Texas-Mexico border was explored, providing third grade students in both treatment and control groups ( $n = 141$ ). This study focused solely on participants who identified as ELs participating in both treatment and control groups. In order to participate in the study, participants were required to have both their pre-and posttest scale score regarding picture vocabulary and pre- and posttest scale score regarding verbal analogies.

### **Context of the Study**

The present study took place in a large, urban school district in South Texas on the Texas-Mexico border. This school district's student profile in 2017 demonstrated that 98.57% of their students were Hispanic and approximately 95.74% are Economically Disadvantaged. Additionally, 14,821 or 32.52% are labeled "Limited English Proficient" ("Brownsville TX

Population”, 2018). This district was chosen because in addition to working with ELs and economically disadvantaged, its position on the Texas-Mexico border makes for a high level of immigrant students coming in and out of the United States regularly. Providing appropriate schooling for ELs, including, but not limited to immigrant ELs, is of utmost importance during this time in America. In addition to their service to ELs, it should be noted that this school district was awarded the Broad Prize for Urban Education in 2008 making it the most improved urban school district in the nation (Long, 2008).

### **Program Intervention**

The students participating in the treatment group received 28 weeks of content reading integrating science for English language and literacy acquisition. This intervention aligned all instruction to the language art standards required by the state, the Texas Essential Knowledge and Skills (TEKS), the science standards (TEKS) required for the third grade, the Next Generation Science Standards (NGSS), and Common Core. In addition to this alignment, and for the purposes of the study, English Language Proficiency Standards (ELPS) for ELs were also addressed and EL strategies, such as academic language scaffolding, advanced organizers, partner reading, visual scaffolding, etc. were also included.

### **Daily Objectives**

Each day, students were given daily content objectives and language objectives to help strengthen their English language skills and reinforce their learning for mastery. The content objective reflected the science standard required by state. These objectives included the necessary academic vocabulary (such as magnet, force, or gravity) that correlated with the

science unit of study. Language objectives included a focus on English language development. Through the language objectives, students focused on the relationship of sounds and letters, demonstrated understanding through verbal questioning, as well as responded about the content objective through writing.

### **Science Inquiry**

Teachers were provided with the materials for daily 45-minute lesson plans following the 5-E model of instruction (Engage, Explore, Explain, Elaborate, and Evaluate). This science model of instruction follows an inquiry-based format that encourages a complex level of thinking (Huerta, 2013). In addition to providing a method for discovery and exploration, the 5-E model allows educators to deliver science lessons while drawing on students' background knowledge, motivation for discovery, and includes scaffolds to stimulate thinking (Huerta, 2013). Each 45-minute lesson was designed to seamlessly incorporate each piece of the 5-E model (Engage, Explore, Explain, Elaborate, and Evaluate).

Before the initial *Engage* stage, teachers were encouraged to review their Teacher Background, What to Expect, and Lab Support sections of their teacher's editions in order to strengthen their understanding of the science concepts. In addition to this, each teacher was expected to have previously prepared materials for easy access and flow of the lesson. Table 1 provides a detailed description of the 5-E model components.

Table 1

*The 5-E Model*

Stage	Purpose	Examples
Engage	The purpose of this stage is to capture students' attention. This time also allows the teacher to assess background knowledge and discover misconceptions.	dramatic reading, demonstration, powerful quote, showing a picture
Explore	The purpose of the explore stage is to work collaboratively to construct knowledge based on concrete experiences. The teacher can later use this experience to teach the concept.	collecting data, building models, make or test hypothesis,
Explain	The purpose of this stage to allow for learners to build their ideas and discuss the explanations of those ideas in their own words. The teacher is expected to clarify misconceptions and connect the learning to the activity that occurred within the engage and explore stages.	partner discussion, debate, writing activity, oral presentations, group gallery walks
Elaborate	The purpose of this stage to is extend the learning. Students may still have misconceptions; thus, this it is important to apply the learning and extend their thinking beyond what was explored. During this application stage, the teacher may plan to build upon the previous concept and go deeper.	apply thinking to a new situation, compare learning to another model, apply learning to a related concept
Evaluate	The purpose of this stage is to observe students as they apply their learning and show their ability to do so successfully. The teacher plans ways students can authentically demonstrate mastery of learning.	formal evaluations, informal evaluations, progress reports, demonstration of mastery of the student learning outcomes

After the engage stage, students were placed into cooperative learning groups with individual job tags designated in order to provide for authentic interactions and opportunities for exploration. Students were given an inquiry activity for the purpose of exploring the science concept first-hand as well as a response sheet to record their observations, notes, responses, or

sketches. Furthermore, throughout the lesson, an integration of English language arts took place. Students were provided with explicit sound pronunciation and vocabulary previews prior to partner reading. This word study piece required that the teacher explicitly teach the letter/sound combinations and the vocabulary terms and their meanings which included the letter/sound combinations just taught. Literacy components are integrated directly into the science concepts.

As students read with their partner from their student book, they were encouraged to help each other by sounding out any tricky words. When finished, partner reading discussion cards were available to guide student talk and allow for a quick comprehension check. Linguistic accommodations were also available for those with lower English reading Proficiency in order to provide an opportunity for these students to attain. Moreover, extension activities were provided for students to practice cross-curricular subjects such as mathematical word problems with the particular science concept. Table 2 illustrates a scripted lesson plan from Project CRISELLA following the 5-E model.

Table 2

*Sample CRISELLA Scripted Lesson Plan Following 5-E Model*

Week 4, Day 1, 45 Minutes		
<b>Daily Objectives</b>	<b>Content Objectives-</b> Students will explore gravity on an object gives an object weight using common classroom objects.	<b>Language Objectives-</b> Students will learn relationships of sounds and letters in English and partner read grade level expository text and check for understanding using Partner Reading Discussion Questions.
<b>Engage (~5 min)</b>	Listen to this scenario. Marcos pulled his brother down the street in a wagon. He remembered what he learned at school about forces, motion, and work. Marcos tells his brother that pulling the wagon is an example of work. Identify whether Marcos is using a push or pull to move the wagon.	
<b>Explore (~17 min)</b>	<p><b>Exploratory Question: What can magnetic force move?</b> Today you are going to work in groups to explore another example of how force causes motion. Materials managers please carefully bring the trays of materials to your tables. Before we start the activity, take the magnet and test the magnetism of objects around the room.</p> <p>Step 1: Student places an object in the circle.  Step 2: Observe: Bring the magnet close to the edges of the circle. Observe which objects move.  Step 3: Record: List the objects that the magnet moved.  Step 4: List the objects that the magnet did not move outside the circle.  Step 5: Infer: Use what you observed to describe magnetic force.  Sentence Stem: Magnetic force moved _____. Magnetic force did not move ____.</p> <p>Let's discuss your investigation.</p> <ul style="list-style-type: none"> <li>• <b>Identify objects that the magnet did not move.</b></li> <li>• <b>Identify objects that the magnet did move.</b></li> </ul>	
<b>Explain (~20 min)</b>	<p>Pre-Reading: Sound Pronunciation and Vocabulary Preview</p> <p>magnetism – Magnetism is a force that pulls on, or attracts, metal objects containing iron.  noncontact – The prefix non- means not. Contact means when two objects touch each other. So noncontact means not touching. Magnetism is a noncontact force. This means the magnet can pull some objects without touching them.  field – A field is an open area of land. When we talk about magnets, field has a different meaning. A field is a space around the magnet where magnetism is strongest. The field is strongest near the magnet's poles.</p> <ul style="list-style-type: none"> <li>• Place students with reading partners. Turn to page 420-421 in your book.</li> </ul> <p>Remember that you will alternate, or switch reading paragraphs with you partner. Make sure to listen to each other read and help each other sound out tricky words. Then discuss the questions listed on Partner Reading Discussion Card. If you have extra time, re-read the passage.</p> <ul style="list-style-type: none"> <li>• You may begin reading. You will have 6 minutes to read this pages with your partner. Continue reading until you hear me stay 'Stop'. Set timer for 6 minutes as you monitor reading pairs.</li> </ul>	
<b>Elaborate (~2 min)</b>	<p><b>Now let's look at the pictures and read the captions. Remember that pictures and captions help us understand what we are reading. Look at the picture of the crane on p. 420. How do you know that the objects being lifted are made of metal containing iron?</b></p>	
<b>Evaluate (~8 min)</b>	<p>Comprehension Check</p> <p>Discuss Partner Reading Discussion Card using questioning strategies.</p> <ol style="list-style-type: none"> <li>1. Define magnetism.</li> </ol> <p><b>**In which paragraph did you find this evidence for this answer?</b></p> <ol style="list-style-type: none"> <li>2. Discuss why a magnet attracts steel.</li> <li>3. List three items that magnets do not attract.</li> <li>4. Explain why magnets do not attract these items.</li> <li>5. Using your own words, tell your partner what you read.</li> </ol>	



An integration of literacy into the content areas, as the literature has shown, is an effective and essential component in order to help ELs attain scientific literacy (Fang, 2004, 2006). As Fang has stated in the research, engaging students in structured conversations and an integration literacy practices such as an introduction of critical vocabulary words, partner reading, and comprehension checks provide for effective instructional practices for ELs.

### **Research Questions**

For the present study, I proposed to investigate the following four research questions utilizing archived data from a larger study.

The following four questions guided my study:

1. Based on the implementation of a literacy-infused, inquiry-based science curriculum in a Texas-Mexico border school district, to what extent is there a difference between English vocabulary skills of ELs in the treatment group versus the English vocabulary skills of ELs in the control group as measured by the Woodcock Muñoz Survey-Revised picture vocabulary subtest?
2. To what extent is there a difference between the English oral language expressive skills of ELs in the treatment group versus the oral language expressive skills of ELs in the control group as measured by the Woodcock Muñoz Survey- Revised verbal analogies subtest?
3. Is there a difference between male and female ELs in oral language expressive skills and English vocabulary as measured by Woodcock Muñoz Survey-Revised picture vocabulary and verbal analogies subtests?

4. Is there a difference that exists between classrooms utilizing the literacy-infused, inquiry-based science curriculum and those who are not, in relation to “student-talk” and/or “teacher-to-student interactions” in either English or Spanish academic language?

### **Instrumentation**

Pre- and post-tests archived data from the Woodcock Muñoz Language Survey-Revised were used to determine the impact on English vocabulary development and more specifically, English oral language expression between those ELs who participated in the treatment group and those ELs who participated in the control group. The Woodcock Muñoz Johnson Survey-Revised includes a series of subtests: Subtest 1: Picture Vocabulary, Subtest 2: Verbal Analogies, Subtest 3: Letter-Word Identification, Subtest 4: Dictation, Subtest 5: Understanding Directions, Subtest 6: Story Recall, and Subtest 7: Passage Comprehension.

For the purposes of this study, and utilizing archived data from the larger study, only subtests 1: Picture Vocabulary and subtest 2: Verbal Analogies were used to answer research questions one, two, and three. Subtest 1: Picture Vocabulary measured verbal knowledge by asking for the examinee to identify pictured objects (WMLS-R). The items become increasingly difficult as the pictured objects appear less frequently in the environment (WMLS-R). According to the Woodcock-Muñoz Language Survey- Revised, Subtest 1: Picture Vocabulary has a “median reliability of .79 in the 5 to 18 age range” (WMLS-R, p.14). Subtest 2: Verbal Analogies has a “median reliability of .86 in the 5 to 18 age range” and measures the ability of the examinee to orally communicate with coherency and specified words (WMLS-R, p.13). Again, the specified words required to be utilized by the examinee at times are joined with a

picture, but as the items become increasingly difficult, the visual cues are taken away and the specified words are those which are less and less frequently used or heard in the environment. When combined, both subtests created an academic cluster addressing the abilities of oral language expression.

In order to address research question number four, Is there a difference that exists between classrooms utilizing the literacy-infused, inquiry-based science curriculum and those who are not, in relation to “student-talk” and/or “teacher-to-student interactions” in either English or Spanish academic language?, archived observational videos previously coded from the larger study (ELLA-V), utilized the Transitional Bilingual Observation Protocol (TBOP).

The TBOP is a tool co-developed by Lara-Alecio and Parker in which key elements of classroom instruction can be identified and observed for further analysis (Lara-Alecio & Parker, 1994). This validated pedagogical model “(a) possesses explanatory and predictive power, over time (stability), and across a range of classroom situations (generalizability), (b) is instructionally useful (positively affects student growth when used for lesson planning), (c) is parsimonious (simply integrates a large number of variables), and (d) interrelates with other pedagogical models” (Lara-Alecio & Parker, 1994, p. 125).

Because the model is useful in collecting observational data, particularly in Bilingual/ESL classrooms, it’s use in this present study is vital as it provides an opportunity to analyze a variety of domains: a) Activity Structures, b) Language Content, c) Language of Instruction, and d) Communication Mode (Lara-Alecio & Parker, 1994). When looking at the element, Activity Structures, as outlined in the TBOP, the focus is on teacher behavior and student behavior and the combination, therein. Examples of the coding for this element are

Lectures (LEC), Leads (LED), or Demonstrates (DEM). Example of coding student behavior for this element are Discovers (DIS), Performs (PER), and Cooperates (COP).

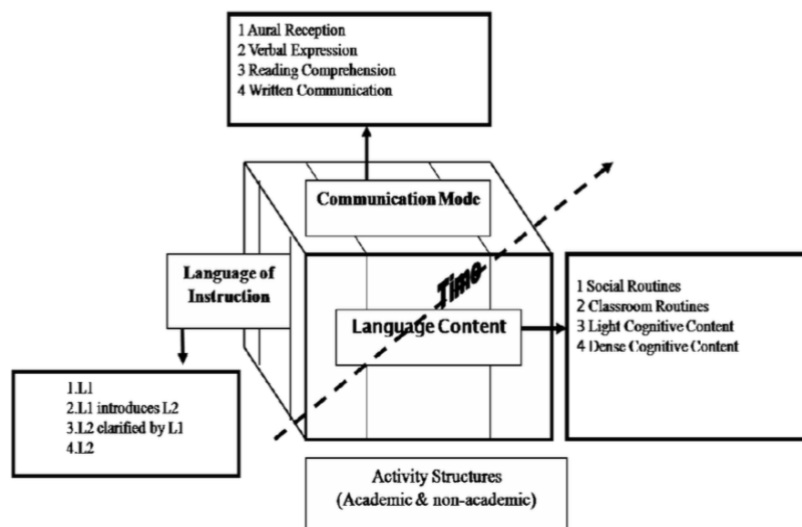
Another element identified and possibly observed in the TBOP is Language Content. This second dimension is structured upon Cummins' 1986 research regarding BICS and CALP proficiencies. Rather than identify these proficiency levels as fixed outcomes, the TBOP reformulates these observable abilities as pliable levels of dialogue (Lara-Alecio & Parker, 1994). In addition to the two competencies, the TBOP includes two additional levels for observation of language content. The description of the levels are as follows: (a) Social Routines (i.e. BICS or social conversation); (b) Academic Routines (i.e. learning strategies, preparing for free-time); (c) Light Cognitive Content (i.e. discussions and current events); (d) Dense Cognitive Content (i.e. content-area information and learning specialized vocabulary). This is important to note because Lara-Alecio and Parker implies that students may not establish BICS in all situations entirely and proceed with attaining CALP; rather, students may be ready for English instruction in some components of classroom instruction, but may need native language for other parts of their school day (Lara-Alecio & Parker, 1994). Thus, the TBOP is used to identify language content and the transition from L1 to L2 as it occurs for different times and activity structures.

The third dimension, Language of Instruction can be measured by observing the different combinations of native language and English that is utilized throughout the instruction (Lara-Alecio & Parker, 1994). The TBOP identifies four combinations. The first combination is indicated when native language is used to present content first in cases where student have low English proficiency and are identified as beginning English learners, the second combination occurs when the native language is utilized to introduce the second language. This indicates that

native language was used for instruction; however, key vocabulary terms, key ideas, and concepts were reinforced and bridged to the second language. The third combination is identified when the second language is clarified by the native language indicating that English was used as an initial teach while the native language is used as a clarification piece. The fourth and final combination is identified when content is presented in second language only (Lara-Alecio & Parker, 1994).

Language Mode or Communication Mode is the fourth element included in the TBOP observational tool. This identifies many modalities (aural reception, verbal expression, reading comprehension, and written communication) which may be included in the activity structure of the school day and the language utilized in these modalities (Lara-Alecio & Parker, 1994). To clarify, this element identifies when either the native or second language is utilized in a specific modality. For example, students may be required to read a short passage in English; however, they may be allowed to discuss the main points of the passage in the language of their preference, native language or English (Lara-Alecio & Parker, 1994).

Figure 3 shows a visual of the four-dimensional Transitional Bilingual Pedagogical Theory co-developed by Lara-Alecio and Parker (1994) and the interaction of the four elements.



*Figure 3: Four-dimensional Transitional Bilingual Pedagogical Theory reprinted from (Lara-Alecio & Parker, 1994).*

For the purposes of this study and to answer research question number four, I used the domain: activity structures and the student language therein of the TBOP to examine “student-talk” and/or “teacher-to-student interactions” in either English or Spanish academic language between conditions.

### **Data Collection**

In order to complete this study, I utilized archived data collected from a larger study, ELLA-V, and the study within, CRISELLA, and only focused on an urban school district serving ELs located on the Texas-Mexico border. The data were shared with me with permission from the Principal Investigator of ELLA-V. Access to observation videos and TBOP coded results

from the archived data were used to complete the statistical analysis of the two-way ANCOVA and chi-square test for homogeneity.

### **Data Analysis**

The statistical analysis best suited in the present study is a quantitative comparative analysis through a two-way analysis of covariance (ANCOVA) across groups in which subjects had been randomly assigned. The two-way ANCOVA is appropriate for this present study because it allows one to observe the difference for two independent variables and one dependent variable according to their adjusted means, the covariate. Through this statistical analysis, I compared the effects of a literacy-infused, inquiry-based science intervention on ELs' expressive oral language and vocabulary development and those ELs who were randomly assigned to the control group receiving instruction as designated by the school district policy. Furthermore, a two-way ANCOVA allowed for an analysis of interaction between the factors while accounting for the pre-test score which can explain a large amount of variance in the post-test scores.

In addition to the quantitative comparative analysis, this study will also include a Chi-square test for homogeneity. Utilizing data gathered from the Transitional Bilingual Observation Protocol (TBOP), the Chi-square test for homogeneity statistical analysis will help to collect the frequency in which "student-talk" and/or "teacher-to-student interactions" in either English or Spanish academic language occurred in both treatment and control group classrooms. The chi-square test of homogeneity will assist to analyze the frequency of activities in the different classrooms and the student language occurrences within the category of activity structures, as expressed on the TBOP and determine whether the archived data analyzed was homogenous or differed among treatment and control groups.

To begin the data analysis process and in order to answer the first three questions regarding the impact of the intervention on the treatment group versus the control group in the areas of picture vocabulary and verbal analogies while accounting for the covariate, pre-test scores, and taking into account another factor: gender, a two-way Analysis of Covariance (ANCOVA) test was used. The ANCOVA analysis is appropriate to use for this study because in addition to the randomization of the study, the results cannot be misinterpreted by the variance within and between groups as it will help us draw inferences while accounting for the covariate. Specifically, a two-way ANCOVA analysis is necessary because it is used to determine whether or not there is an interaction effect between the two independent variables, treatment and gender, on the continuous dependent variable, post-test results.

First, in order to complete the two-way ANCOVA analysis on the Statistical Package for Social Sciences (SPSS) software, a univariate analysis of variance (ANOVA) was used to test the assumptions. One of the assumptions is to calculate the differences between groups. The Levene's Test of Equality of Error Variance helped to determine if there is about the same or different amounts of variability between scores. When the Levene's test stated that the p-value  $<.05$ , then the variances between populations were described as equal, and could then be concluded that the variability in the two groups is not statistically significant. Moreover, when the two-way ANCOVA was calculated, the test between-subjects effects, disclosed by accounting for the covariate: pre-test, that there was a difference between ELs who received the treatment versus those ELs who did not. The results indicated that the p-value  $<.05$ , then the posttest means are statistically significant by condition, and it can be concluded that the ELs who partook in the intervention scored higher in the areas of picture vocabulary and verbal analogies.



In order to answer question four: Is there a difference that exists between classrooms utilizing the literacy-infused, inquiry-based science curriculum and those who are not, in relation to “student-talk” and/or “teacher-to-student interactions” in either English or Spanish academic language? a Chi-square test for homogeneity was the statistical analysis used to collect the frequency in which “student-talk” and/or “teacher-to-student interactions” in either English or Spanish academic language occurred in both treatment and control group classrooms during specific activity structures. The chi-square test of homogeneity assisted to determine if the frequency of occurrences within the category of “activity structures and student language”, as expressed utilizing the TBOP, was homogenous or differed among treatment and control groups.

### **Limitations**

A limitation in utilizing data from this larger project of ELLA-V, CRISELLA is the initial sample included 159 participants; however, 18 participants, for whatever reasons had missing data: pretest scores for either picture vocabulary or verbal analogies. This decreased the number of participants making the sample size smaller than originally planned; however, this sample size is adequate to meet the statistical needs of this present study.

## **CHAPTER IV**

### **DATA ANALYSIS AND FINDINGS**

This chapter includes the results of the proposed methods and statistical analysis I conducted as a means to answer the four major research questions driving the present study. Each question is presented with the results following thereafter. First, it should be noted that the statistical analysis which took place in this study was a Two-Way ANCOVA analysis in which research questions 1 – 3 were addressed. A Two-Way ANCOVA was appropriate because the analysis would indicate the impact of the intervention on the treatment group versus the control group in the areas of picture vocabulary and verbal analogies while accounting for the covariate, pre-test scores, and taking into account the interaction of the intervention with another factor: gender. After conducting the Two-Way ANCOVA statistical analysis, using archived data collected from a larger study, the results indicated that for both domains, picture vocabulary and verbal analogies, treatment classrooms had higher means on post-tests in comparison to the control classrooms. Additionally, there were no differences due to the interaction between gender and the intervention that were noted in the results.

For research question number four, it was necessary to utilize archived data gathered from the Transitional Bilingual Observation Protocol (TBOP), the Chi-square test for homogeneity statistical analysis helped to analyze a collection of frequency data in which “student-talk” and/or “teacher-to-student interactions” were observed in either English or Spanish academic language which occurred in both treatment and control group classrooms. The chi-square test of homogeneity assisted to analyze the frequency of activities in the different classrooms and the student language occurrences within the category of activity structures, as expressed on the TBOP. It helped to determine whether the archived data analyzed was

homogenous or differed among treatment and control groups. Additionally, postulations could be made from the Chi-Square statistical analysis and the effect size as it was calculated using Cramer's V. I used the standards developed by Cohen (1988) as guidelines to measure effect size. They are as follows: small =.10, medium =.30 and large =.50.

### Research Question One

Research question one was-- Based on the implementation of a literacy-infused, inquiry-based science curriculum in a Texas-Mexico border school district, to what extent is there a difference between English oral language expressive skills of ELs in the treatment group versus the English oral language expressive skills of ELs in the control group as measured by the Woodcock Muñoz Survey-Revised? In order to address this question, the results from the Two-Way ANCOVA analysis, a crosstabulation of the oral language expressive skills, specifically the scores from the picture vocabulary subtest was calculated. Table 3 shows the descriptive statistics of pre-and post-test scores for picture vocabulary.

Table 3  
*Descriptive Statistics of Pre- and Post-test Scores on Picture Vocabulary Subtest by Condition*

Measure		Condition					
		Control			Treatment		
		n	M	SD	n	M	SD
Picture Vocabulary	pre	77	77.62	25.75	64	76.59	27.06
	post	77	81.13	20.37	64	84.94	21.07

*Note.* Originally, there were a total of 159 students participating in the study: eighty-six students in the control group and seventy-three students in the treatment groups. Due to attrition and some incomplete scores for either picture vocabulary or verbal analogies subtests, some participants were not included in the analysis. A total of 141 students had pre- and post-test scores in the picture vocabulary subtest: 77 were in the control group and 64 in the treatment group.

Data from Table 3 shows that there are approximately the same number of participants in both conditions, treatment ( $n=64$ ) and control ( $n=77$ ). Additionally, the means at the pre-test mark for both control ( $M=77.62$ ) and treatment ( $M=76.59$ ) are similar. This is also true for the standard deviation. The standard deviation, as listed in Table 3 is 25.75 for the pre-test scores in the control group. The standard deviation, as listed in Table 3 is 20.37 for the post-test scores in the control group. In the treatment group, the standard deviation resulted as 27.06 in the pre-test scores. In the post-test scores, the standard deviation resulted in 21.07 in the treatment groups.

Still, while accounting for the covariate, the pre-test scores, the post-test means, show that while both conditions made gains, the treatment group had a greater post-test mean in comparison to those who participated in control classrooms.

## Research Question Two

Research question two was-- To what extent is there a difference between the English oral language expressive skills of ELs in the treatment group versus the oral language expressive skills of ELs in the control group as measured by the Woodcock Muñoz Survey- Revised verbal analogies subtest? In order to address this question, the results from the Two-Way ANCOVA analysis, a crosstabulation of the oral language expressive skills, specifically the scores from the verbal analogies subtest was calculated. Table 4 shows the descriptive statistics of pre-and post-test scores for verbal analogies.

Table 4  
*Descriptive Statistics of Pre- and Post-test Scores on Verbal Analogies Subtest by Condition*

Measure		Condition					
		Control			Treatment		
		n	M	SD	n	M	SD
Verbal Analogies	pre	81	84.72	15.74	64	85.60	16.96
	post	81	88.29	11.31	64	92.00	11.44

*Note.* Originally, there were a total of 159 students participating in the study: eighty-six students in the control group and seventy-three students in the treatment groups. Due to attrition and some incomplete scores for either picture vocabulary or verbal analogies subtests, some participants were not included in the analysis. A total of 145 students had pre- and post-test scores in the verbal analogies subtest: 81 were in the control group and 64 in the treatment group.

Data from Table 4 shows that pre-test means as well as the standard deviations were similar by condition. In order to compare post-test means, the ANCOVA analysis accounted for the covariate, the pre-test scores. Post-test means show that while both groups made gains, the treatment group had a greater post-test mean in comparison to those who participated in control classrooms.

### Research Question Three

Research question three was-- Is there a difference between male and female ELs in oral language expressive skills and English vocabulary as measured by Woodcock Muñoz Survey-Revised picture vocabulary and verbal analogies subtests? In order to address this research question, a Two-Way ANCOVA (also referred to as a “factorial ANCOVA”) was conducted. This statistical analysis was vital in determining whether or not there was an interaction effect between the two independent variables, the intervention and gender, while accounting for the covariate, the pre-test scores. Table 5 illustrates the breakdown of ELs by gender during the initial pre-test from the particular urban school district of focus located on the Texas-Mexico border.

Table 5

*Descriptive Statistics of Picture Vocabulary Pre-tests by Gender*

Measure	Condition					
	Pre-test					
	Control			Treatment		
Picture Vocabulary	n	M	SD	n	M	SD
Females	37	79.49	22.99	27	75.59	31.08
Males	40	75.83	27.94	37	77.62	23.77
Total	77	77.58	25.58	64	76.77	26.88

*Note.* Originally, there were a total of 159 students participating in the study: eighty-six students in the control group and seventy-three students in the treatment groups. Due to attrition and some incomplete scores for either picture vocabulary or verbal analogies subtests, some participants were not included in the analysis. A total of 141 students had pre- and post-test scores in the picture vocabulary subtest: 77 were in the control group and 64 in the treatment group.

As indicated in Table 5, the post-test by gender and condition are shown. It is important to note that while there may have initially 159 ELs participating in the study, 18 students were not included due to lacking either an initial pre-test scale score or failure to have a post-test scale score for either measure. Thus, the present study analyzed a total of 141 scores of ELs in this

particular school district. Furthermore, it is important to note that females and males were evenly represented in both conditions. Table 6 shows the descriptive statistics for post-test results by gender and condition. As indicated by both Table 5 and Table 6, out of the initial 159, only 77 ELs participated in the control group and 64 ELs participated in the treatment group. Their mean scores and standard deviations are listed for the pretest from the Woodcock Muñoz Survey-Revised picture vocabulary measure.

Table 6  
*Descriptive Statistics of Picture Vocabulary Post-tests by Gender*

Measure	Condition					
	Post-test					
	Control			Treatment		
	n	<i>M</i>	<i>SD</i>	n	<i>M</i>	<i>SD</i>
Picture Vocabulary						
Females	37	81.89	16.75	27	84.33	25.20
Males	40	80.28	23.21	37	85.51	17.51
Total	77	81.05	20.25	64	85.02	20.58

*Note.* Originally, there were a total of 159 students participating in the study: eighty-six students in the control group and seventy-three students in the treatment groups. Due to attrition and some incomplete scores for either picture vocabulary or verbal analogies subtests, some participants were not included in the analysis. A total of 141 students had pre- and post-test scores in the picture vocabulary subtest: 77 were in the control group and 64 in the treatment group.

For the verbal analogies measure, Table 7 lists the initial pre-test results for students by gender and by condition. Out of the initial 159, only 81 ELs participated in the control group and 64 ELs participated in the treatment group.

Table 7

*Descriptive Statistics of Verbal Analysis Pre-tests by Gender*

Measure	Condition					
	Pre-test					
	Control			Treatment		
Verbal Analogies	n	<i>M</i>	<i>SD</i>	n	<i>M</i>	<i>SD</i>
Females	40	88.25	12.05	27	82.56	20.30
Males	41	82.24	17.77	37	86.78	15.17
Total	81	85.21	15.42	64	85.00	17.50

*Note.* Originally, there were a total of 159 students participating in the study. Eighty-six students in the control group and seventy-three students in the treatment groups. Due to attrition and some incomplete scores for either picture vocabulary or verbal analogies subtests, some participants were not included in the analysis. A total of 145 students had pre- and post-test scores in the verbal analogies subtest: 81 were in the control group and 64 in the treatment group.

Table 8 lists descriptive information for the verbal analysis post-test results by gender and condition. Again, noting that out of the initial 159, only 81 ELs participated in the control group (male and female) and 64 ELs participated in the treatment group (male and female).

Table 8

*Descriptive Statistics of Verbal Analysis Post-tests by Gender*

Measure	Condition					
	Post-test					
	Control			Treatment		
Verbal Analogies	n	<i>M</i>	<i>SD</i>	n	<i>M</i>	<i>SD</i>
Females	40	90.93	9.27	27	91.37	15.04
Males	41	86.02	12.43	37	91.84	8.74
Total	81	88.44	11.19	64	91.64	11.71

*Note.* Originally, there were a total of 159 students participating in the study. Eighty-six students in the control group and seventy-three students in the treatment groups. Due to attrition and some incomplete scores for either picture vocabulary or verbal analogies subtests, some participants were not included in the analysis. A total of 145 students had pre- and post-test scores in the verbal analogies subtest: 81 were in the control group and 64 in the treatment group.



When conducting a two-way ANCOVA, several assumptions must be made in order to ensure that it is the appropriate statistical analysis to use: a) that the covariate was measured prior to the experimental manipulation or treatment, b) the covariate was measured accurately, c) there is a linear relationship between the dependent variable and the covariate, and d) the relationship between the covariate and the dependent variable is the same for each of the groups or homogeneity between groups.

Although the present study was derived from a larger study in which the research design was a randomized control trial assigning ELs randomly to both the control and treatment groups, a Levene's Test of Equality of Error Variances was helpful to determine if there is about the same or different amounts of variability between scores within the groups. Utilizing the archived data from the larger study, a Levene's Test is appropriate to use if the groups have similar variances. Table 9 illustrates the results of the Levene's Test of Equality of Error Variances for both control and treatment groups and both measures: picture vocabulary and verbal analogies.

Table 9

*Levene's Test of Equality of Error Variances for Control and Treatment Groups for Picture Vocabulary and Verbal Analogies*

Measure	<i>F</i>	<i>df1</i>	<i>df2</i>	<i>p</i> value
Picture Vocabulary Post-Test	1.792	3	137	0.152
Verbal Analogies Post-Test	2.02	3	141	0.114

Levene's Test tested whether the variances of the groups were approximately equal. Unlike a t-test, it is important for Levene's test to be nonsignificant. This F-test, as shown in Table 9 shows that in the case of both measures, picture vocabulary and verbal analogies, are

nonsignificant. For picture vocabulary, Levene's statistic is reported as  $F(3,137) = 1.792$ ,  $p=0.152$  and for verbal analogies can be reported as  $F(3, 141) = 2.02$ ,  $p=0.114$ . Thus, it can be assumed that the variances between groups is equal.

A two-way ANCOVA analysis was appropriate for this present study because it would help to reduce within-group variance while assessing the impact of the intervention in comparison to the control group and the interaction of the intervention and gender. In addition, this statistical analysis reduces the variability that cannot be explained in terms of the covariate. Table 10 illustrates the results of the ANCOVA analysis between groups in regards to the picture vocabulary measure.

Table 10  
*ANCOVA Results for Picture Vocabulary*

Source	Test of Between-Subjects Effects					
	Type III Sum of Squares	df	Mean Square	F	p value	Partial Eta Squared
Corrected Model	48357.172 <sup>a</sup>	4	12089.293	150.581	<.001	0.816
Intercept	11458.45	1	11458.45	142.723	<.001	0.512
Pre-test Picture Vocabulary	47736.085	1	47736.085	594.586	<.001	0.814
Gender	4.476	1	4.476	0.056	0.814	0.000
Condition	723.606	1	723.606	9.013	0.003	0.062
Gender * Group	13.169	1	13.169	0.164	0.686	0.001
Error	10918.7	136	80.285			
Total	1027142	141				
Corrected Total	59275.872	140				

a. R Squared = .816 (Adjusted R Squared = .810)

b. Computed using alpha = .05

Looking first at that the interaction between gender by condition (treatment and control), there is not a significant effect as indicated by the p-value (0.686). However, Table 10 indicates, when controlling for the covariate, pretest scale score in picture vocabulary across both control

and treatment groups, the results indicated that the intervention was statistically significant ( $p = .003$ ). There is a zero percent chance that the difference in mean scores based on treatment groups happened unintendedly. When looking at the F-value results from the two-way ANCOVA analysis, it is evident that the  $F(1, 136) = 9.013$ ,  $p = 0.003$ . Again, these results indicate that there was a significant difference in posttest scores in the area of picture vocabulary between the control and treatment group, while adjusting for pretest scores in the same measure.

In addition, when looking at specifically, gender, the results indicate that this factor is not statistically significant. This means that we can rule gender out as a factor which impacts the dependent variable, or the post-test mean scores. This indicates that gender by condition has no positive or negative affect on the outcome variable, post-test mean scores. Table 11 illustrates the results of the ANCOVA analysis for the Verbal Analogies subtest.

Table 11  
*ANCOVA Results for Verbal Analogies*

Source	Test of Between-Subjects Effects					
	Type III Sum of Squares	<i>df</i>	Mean Square	<i>F</i>	<i>p</i> value	Partial Eta Squared
Corrected Model	11754.613 <sup>a</sup>	4	2938.653	56.658	<.001	0.618
Intercept	9709.14	1	9709.14	187.194	<.001	0.572
Pre-test Picture Vocabulary	10899.728	1	10899.728	210.149	<.001	0.600
Gender	106.19	1	106.19	2.047	0.155	0.014
Condition	417.42	1	417.42	8.048	0.005	0.054
Gender * Group	0.229	1	0.229	0.004	0.947	0.000
Error	7261.346	140	51.867			
Total	1189739	145				
Corrected Total	19015.959	144				

a. R Squared = .816 (Adjusted R Squared = .810)

b. Computed using alpha = .05

Looking first at that the interaction between gender by condition (treatment and control), there is not a significant effect as indicated by the p-value (0.947). As Table 11 indicates, when controlling for the covariate, pretest scores in verbal analogies across both control and treatment groups, the results indicated that the intervention was statistically significant ( $p=0.005$ ). There is a zero percent chance that the difference in mean scores based on treatment groups happened unintendedly. The effect of the intervention, while looking at the p-value is statistically significant. This is evident by looking at the Test statistic,  $F(1, 140)= 6.884$ ,  $p=0.01$ . Over, these results indicate that there was a significant difference in posttest scores in the area of verbal analogies between the control and treatment group, while adjusting for pretest scores in the same measure. Similarly, gender was not a factor that had a statistically significant on the continuous variable. Thus, it is not a factor which would have a main effect on post-test scores.

#### Research Question Four

Research question number four was-- Is there a difference that exists between classrooms utilizing the literacy-infused, inquiry-based science curriculum and those who are not, in relation to “student-talk” and/or “teacher-to-student interactions” in either English or Spanish academic language? A Chi-Square statistical analysis was completed to address this question. A Chi-Square analysis was appropriate to use because the data uses categorical variables; data that does not have rank or order. For this present study, we are examining archived data used with permission from the principal investigator of the ELLA-V (PR/Award Number U411B120047). From 20-second observational videos gathered from both treatment and control classrooms, I analyzed the TBOP domain, activity structures and examined the student language utilized therein. The following table, Table 12, demonstrates the number of observational videos gathered from the two groups.

Table 12

*Number of 20-Second Observational Videos by Condition*

	Treatment	Control	Total
N	1080	1019	2099
%	51.45%	48.54%	

Table 12 demonstrates that there are approximately an equal number of 20-second observational videos in both treatment and control. This helps the present study in providing comparable data from both treatment and control groups.

When conducting the Chi-Square analysis for this study, it was first imperative to include a crosstabulation of activity structures by condition. Particularly, what was of interest first, was how the two groups, treatment and control, differed in activity structures. Table 13 demonstrates the differences.

Table 13

*Crosstabulation of Activity Structures by Condition*

Activity		Condition	
		Treatment	Control
LEC/LIS	Count	202	300
	% within Condition	18.70%	29.40%
LEC/PER	Count	6	4
	% within Condition	0.60%	0.40%
DIR/LIS	Count	78	104
	% within Condition	7.20%	10.20%
DIR/PER	Count	52	95
	% within Condition	4.80%	9.30%
DEM/LIS	Count	0	1
	% within Condition	0.00%	0.10%
LED/PER	Count	73	35
	% within Condition	6.80%	3.40%
ASK/PER	Count	5	25
	% within Condition	0.50%	2.50%
ASK/ANS	Count	281	199
	% within Condition	26.00%	19.50%
ANS/ASK	Count	4	16
	% within Condition	0.40%	1.60%
EV/PER	Count	258	56
	% within Condition	23.90%	5.50%
OBS/PER	Count	40	24
	% within Condition	3.70%	2.40%
EV/COP	Count	4	24
	% within Condition	0.40%	2.40%
OBS/COP	Count	1	2
	% within Condition	0.10%	0.20%
NA/FREE	Count	0	8
	% within Condition	0.00%	0.80%
NA/FEED	Count	7	18
	% within Condition	0.60%	1.80%
NA/TRAN	Count	65	107

Table 13 Continued

	% within Condition	6.00%	10.50%
NA/INT	Count	2	1
	% within Condition	0.20%	0.10%
INTERACT	Count	2	0
	% within Condition	0.20%	0.00%
	Count	1080	1019
	% within Condition	100.00%	100.00%

Table 13 indicates that control classrooms spent more time (29.40%) in the first activity described, lecture and listen (LEC/LIS), during the observed 20 second intervals than treatment classrooms (18.70%). In fact, out of the 100% of the 20 second intervals observed, this activity was found to be the highest for the control classrooms. This was not true for the treatment classrooms. The activity with the largest percentage (26.00%) in treatment classrooms was ask and answer (ASK/ANS); this activity was only found 19.50% of the observed time in control classrooms. During this activity structure, students are asked questions and are required to answer. For specifics on the language students were speaking when they responded during this particular activity see Table 15.

Table 15 also shows a large difference between treatment and control classrooms in evaluate and performance (EV/PER). Treatment classrooms utilized this activity structure 23.9% of their observed time, while control classrooms utilized this activity structure only 5.5% of their observed time. This is important to note because based on the data treatment classrooms provided time for students to perform academic activities, while the control classrooms had less opportunities to engage in evaluative performances.

Overall, utilizing the Chi-Square analysis demonstrated that there are differences that exist in the time allocated for the variety of activity structures between treatment and control

classrooms. While the Chi-Square can calculate if there a statistically significant difference between the groups, the Cramer's V statistic is used to find the strength of the effect size as recommended by Cohen (1988) cutoff values. The values utilized to report and interpret the effect sizes are as follows: small effect = 0.10; medium effect = 0.30; large effect = 0.50 (Cohen, 1988). According to Cohen, the effect size of the analysis is medium to large.

In total, there were 2099 observation videos collected. In the different classrooms, as initially stated in Table12, a total of 1080 observation videos were collected from the treatment group and 1019 observation clips were collected from the control groups. Results in the domain of activity structures indicate that there was a statistically significant difference between treatment and control teachers ( $X^2 = 257.178$ ,  $p < 0.001$ , Cramer's  $V = .350$ ).

The study sought to not only take into account "student talk" and "teacher-to-student" interactions, but the language utilized throughout these activity structures. The archived data gathered from the TBOP utilized in the larger study specified the language(s) students were using during the activity structure. Table 14 slows the student language by condition as well as by activity structure.

Table 14  
*Chi-Square Values by Activity Structures and Student Language*

Activity	Chi-Square	df	Cramer's V	p value
LEC/LIS	26.430	4	0.229	<0.001
ASK/ANS	27.102	4	0.238	<0.001
EV/PER	13.111	3	0.204	0.004



Table 15

*Crosstabulation of Student Language by Condition and Activity Structure*

Activity				Condition	
				Treatment	Control
LEC/LIS	Student Language	Spanish	Count	0	6
			% within Condition	0.00%	2.00%
		English	Count	2	34
			% within Condition	1.00%	11.30%
		Spanish - English	Count	0	1
			% within Condition	0.00%	0.30%
		English - Spanish	Count	0	2
			% within Condition	0.00%	0.70%
		NA	Count	200	257
			% within Condition	99.00%	85.70%
	Total		Count	202	300
			% within Condition	100.00%	100.00%
DIR/PER	Student Language	Spanish	Count	0	3
			% within Condition	0.00%	2.10%
		English	Count	6	43
			% within Condition	11.50%	45.30%
		Spanish - English	Count	0	1
			% within Condition	0.00%	1.10%
		English - Spanish	Count	1	2
			% within Condition	1.90%	2.10%
		NA	Count	45	47
			% within Condition	86.50%	49.50%
	Total	Spanish	Count	0	3
			% within Condition	0.00%	8.60%
		English	Count	13	19
			% within Condition	17.80%	54.30%
		NA	Count	60	13
			% within Condition	82.20%	37.10%
LED/PER	Student Language	Spanish	Count	0	3
			% within Condition	0.00%	8.60%
		English	Count	13	19
			% within Condition	17.80%	54.30%
	Total	Spanish	Count	0	3
			% within Condition	0.00%	8.60%
		English	Count	13	19
			% within Condition	17.80%	54.30%
ASK/PER	Student Language	English	Count	4	14
			% within Condition	80%	56%
		NA	Count	1	11
			% within Condition	100%	100%
	Student Language	Spanish	Count	0	9
			% within Condition	0.00%	2.10%
		English	Count	6	43
			% within Condition	11.50%	45.30%

Table 15  
Continued  
ASK/ANS

ANS/ASK	Student Language	English	% within Condition	0.00%	4.50%
			Count	239	160
			% within Condition	85.10%	80.40%
		Spanish - English	Count	0	2
			% within Condition	0%	1%
			Count	2	10
		English - Spanish	% within Condition	0.7%	5.00%
			Count	40	18
			% within Condition	14.20%	9.00%
		Total	Count	281	199
			% within Condition	100%	100%
			Count	0	1
		Spanish	% within Condition	0.00%	6.30%
			Count	4	15
			% within Condition	100%	93.80%
		Total	Count	4	16
			% within Condition	100%	100%
			Count	1	1
EV/PER	Student Language	Spanish	% within Condition	0.40%	1.80%
			Count	209	35
			% within Condition	81.00%	62.50%
		English	Count	0	1
			% within Condition	0.00%	1.80%
			Count	48	19
		English - Spanish	% within Condition	18.60%	33.90%
			Count	258	56
			% within Condition	100%	100%
			Count	37	11
OBS/PER	Student Language	English	% within Condition	92.50%	45.80%
			Count	3	13
			% within Condition	7.50%	54.20%
		NA	Count	40	24
			% within Condition	100%	100%
			Count	40	24

For the purposes of this study, only the activity structures with highest differences in student language percentages will be discussed. Table 15 indicates that during ASK/ANS activity structures, students in the treatment classrooms responded in English more frequently

(85.10%, n=239) than in control classrooms (80.40%, n=160). Additionally, during the EV/PER activity structure, there exists a large difference in the use of the English language. Treatment classrooms responded in English more frequently (81.00%, n=209) than in control classrooms (62.50%, n=35). Furthermore, in the OBS/PER activity structure, the use of the English language was observed more times in the treatment classrooms (92.50%) than in the control classrooms (45.80%). It is also important to note that there was a difference in control and treatment classrooms during the LEC/LIS in regards to the amount of English used. It was observed that more English was used in control classrooms (11.30%, n=34) as opposed to treatment classrooms (1.00%, n=2).

### **Summary**

In summation, the purpose of this study was to examine the impact of a literacy-infused, inquiry-based science intervention and ELs' expressive oral language and English vocabulary development on pre-and post-assessments, with a focus on a Texas-Mexico border school district. This study also sought to address and add to the literature regarding gender differences on achievement which have been mentioned to exist in STEM classrooms. More specifically, I was also interested in the frequency in which the English language was utilized during a variety of activity structures in the treatment classroom and how it compared to the use of the English language in control classrooms during the same activity structures.

In order to answer the research interests, I analyzed the archived data from a sample of third graders in an urban school district located on the Texas-Mexico border. A Two-Way ANCOVA analysis helped to determine (a) if there were differences in the post-test means on the picture vocabulary subtest of the Woodcock Muñoz Survey-Revised between treatment and

control groups, (b) if there were differences in the post-test means on the verbal analogies subtest of the Woodcock Muñoz Survey-Revised between treatment and control groups, and (c) if there is an interaction effect between the intervention and gender on the oral language expression skills of ELs.

When looking at the difference in the frequency of English language was used by the students between treatment and control groups, a Chi-Square analysis was the statistical analysis that was appropriate to analyze the archived data gathered from the TBOP. The only domain that was analyzed was activity structure by condition. Then, the student language within each activity structure was also analyzed. Once the Chi-Square was calculated and a significance was identified, an additional statistic Cramer's V was used to determine the strength of the differences between treatment and control groups.

The following chapter, chapter five, I will present and discuss the findings, limitations, recommendations, and conclusions of this study.

## **CHAPTER V**

### **DISCUSSION, LIMITATIONS, CONCLUSIONS AND RECOMMENDATIONS**

The ever-changing demographics of the U.S. public school system and an increase of ELs creates a need to address instruction and the impact it has on student achievement, specifically in the areas of STEM (Kohlhaas, 2010). With the implementation of NCLB of 2001, and a call to test science in order to actually teach science, it is not possible to ignore this growing population and their future contributions to society. Additionally, science has been identified as an efficient discipline that can support language development as it allows authentic opportunities for discourse through inquiry (DiRanna & Gomez-Zwiep, 2013). Moreover, researchers have indicated that there exist gender gaps or gender stereotypes inherited by cultural expectations which begin to exhibit as early as first grade (Kohlhaas, 2010). Other researchers who conducted studies with national data reported that males outperformed females in the area of science similar results despite improvement in scores by both gender groups (Grigg, Lauko, & Brockway, 2006).

Focusing on ELs and their language development in the areas of science is crucial due to the changes in the science standards. Before science standards were only concerned with what the “students would know”, and now the NGSS explicitly promote the idea that students utilize the language skills necessary to convey their knowledge (DiRanna & Gomez-Zwiep, 2013). This development of scientific literacy is essential; however, low science performance among ethnic minorities is a continual challenge and often a product of failed opportunities in curriculum and instruction (Kohlhaas, 2010). Other researchers reiterated the dreadful truth that students who do not develop communication patterns commensurate to what is expected to be

utilized in a science classroom will have “difficulty learning new concepts, connecting new learning to their prior knowledge, and expressing their understanding to others (Foster, et al., 2008, p. 81)

Thus, it is essential to look at the opportunities or activity structures that are used in the classrooms for “student-talk” and “teacher-student-interactions” that exist or may be lacking. Because language is how we think, process information, and remember, it would behoove educators to incorporate opportunities to practice developing these skills in our classrooms (Fisher et al., 2008). Still, according to Lesko (2019), teacher-led discussions, teacher-centered discourses and questioning, and teacher-led decision are what is evident and practiced. Furthermore, in a study by Lingard, Hayes, and Mills (2003), they discovered that teachers talked more and students talked less in classrooms in which there were higher numbers of students living in poverty. Again, while not all ELs are poverty-stricken, we also know that typically, these students are asked less questions making it very difficult for students to have opportunities to practice the development of the English language in the classroom at all (Fisher et al., 2008).

Through this present study, I analyzed the impact of a literacy-infused, inquiry-based science intervention, and its effects on the oral language expression of ELs while accounting for the covariate. For the purpose of adding to the literature on the differences between males and females in regards to their achievement, I also looked at the interaction effect of the intervention and gender on the outcome variable, post-test scores in areas of picture vocabulary and verbal analogies. When establishing if there was a difference between treatment and control classrooms in terms of opportunities for “student-talk” and “teacher-to-student interactions”, a Chi-Square test of homogeneity was utilized to determine if the frequency of occurrences of certain activity

structures were homogenous across treatment and control group. In addition to the statistical significance provided by the Chi-Square test, the strength of the significance was determined using Cramer's V effect statistic.

The main purpose of the study is to inform key stakeholders who are involved in the decision making for the education of ELs about the benefits of utilizing an effective method of instruction in the content areas, specifically science. With purposeful content area instruction in disciplines such as science and close attention to classroom routines which provide opportunities for "student-talk" and/or "teacher-to-student" interactions, ELs can make gains in their oral language expression skills and begin to close the achievement gap between themselves and their native English speaking peers particularly in such high-stakes areas as the Texas-Mexico border.

The data from my study were guided by four research questions. Throughout the chapter is a list of discussions in the order according to the research questions previously stated. The following discussions are reflective in nature, of the literature review as well as of the data analysis conducted.

## **Discussion**

### **Research Question 1**

Based on the implementation of a literacy-infused, inquiry-based science curriculum in a Texas-Mexico border school district, to what extent is there a difference between English vocabulary skills of ELs in the treatment group versus the English vocabulary skills of ELs in the control group as measured by the Woodcock Muñoz Survey-Revised picture vocabulary subtest?

A Two-Way ANCOVA was the initial statistical analysis used to determine if there was a difference between treatment and control group on the outcome variable, vocabulary, as

measured by the Woodcock Muñoz Survey-Revised. The Two-Way ANCOVA was appropriate because the analysis included the covariate, pre-test vocabulary scores initially recorded prior to the literacy-infused, inquiry-based intervention that took place in treatment classrooms.

The post-test means for both control and treatment groups were collected and analyzed to see if there was a difference. The results revealed that there was a statistically significant difference between the post-test means of those participants in the treatment group versus the post-test means in the control group. These results indicate that those participants who partook in the intervention made greater gains in the area of picture vocabulary and ultimately, in increasing their oral language expressive skills.

## **Research Question 2**

To what extent is there a difference between the English oral language expressive skills of ELs in the treatment group versus the oral language expressive skills of ELs in the control group as measured by the Woodcock Muñoz Survey- Revised verbal analogies subtest?

The initial Two-Way ANCOVA that was used to answer research question number one, also helped to answer research question number two. The Two-Way ANCOVA statistical analysis determined that there was a difference between treatment and control group on the outcome variable, verbal analogies, as measured by the Woodcock Muñoz Survey-Revised. The post-test means of both the treatment and control classrooms were analyzed while accounting for the pre-test scores as a covariate in the analysis, and it was determined that there was a statistically significant difference in the outcome variable, post-test means in the area of verbal analogies subtest of the Woodcock Muñoz-Survey Revised, the oral language proficiency test.



These results indicate that those participants who partook in the intervention made greater gains in the area of verbal analogies and ultimately, in increasing their oral language expressive skills.

### **Research Question 3**

Is there a difference between male and female ELs in oral language expressive skills and English vocabulary as measured by Woodcock Muñoz Survey-Revised picture vocabulary and verbal analogies subtests?

Again, the Two-Way ANCOVA statistical analysis that was used to answer research question number one and two, also helped to answer research question number three. This research question addressed the gender disparity which has been previously identified in the STEM disciplines. The Two-Way ANCOVA was used to identify the interaction effect between the two independent variables, the literacy-infused, inquiry-based intervention and gender, on the outcome variable, post-test means. The Two-Way ANCOVA results indicated that there was not a statistically significant interaction effect between gender and the intervention. This means that the data shows the intervention does not benefit one gender over the other. The intervention, as indicated by the results in research question one and research question two, benefits ELs in general.

### **Research Question 4**

Is there a difference that exists between classrooms utilizing the literacy-infused, inquiry-based science curriculum and those who are not, in relation to “student-talk” and/or “teacher-to-student interactions” in either English or Spanish academic language?

In order to answer research question number four, a different statistical analysis was used. A Chi-Square Test of Homogeneity determined if the frequency of occurrences in activity structures was homogenous across treatment groups. The calculations determined that in certain activity structures, treatment and control classrooms significantly differed. First, control classrooms spent more time (29.40%) in lecture and listen (LEC/LIS) as opposed to treatment classrooms (18.70%). This demonstrates that teachers in the control classrooms spent more time delivering the lecture (talking) as opposed to having students engaging in talks themselves. It should be noted that out of the 100% of the 20 second intervals observed, this activity was found to be the highest for the control classrooms. This was not true for the treatment classrooms.

In treatment classrooms, the activity with the largest percentage (26.00%) was ask and answer (ASK/ANS). In control classrooms, the opportunities to engage in “student-talk” and “teacher-to-student interactions” was only found 19.50% of the time observed. The results also demonstrated a large difference between treatment and control classrooms in evaluate and performance (EV/PER). In treatment classrooms, this activity structure was observed approximately 23.9%, while only 5.5% was this activity observed in control classrooms. This is important to note because based on the data treatment classrooms provided time for students to perform academic activities, while the control classrooms had less opportunities to engage in evaluative performances. This activity structure would provide an opportunity for students to use the English language.

The Chi-Square analysis demonstrated that there are differences that exist in the variety of activity structures between treatment and control classrooms in which ELs would have opportunities to engage in “student-talk” and/or “teacher-to-student interactions”. The Cramer’s V statistic was used to find the strength of the effect size as recommended by Cohen (1988)

cutoff values. The strength of this statistical analysis was medium to large as the standards developed by Cohen (1988) state the guidelines for effect sizes as follows: small effect = 0.10; medium effect = 0.30; large effect = 0.50). Ultimately, results in the domain of activity structures indicate that there was a statistically significant difference between treatment and control teachers ( $X^2 = 257.178$ ,  $p < 0.001$ , Cramer's  $V = .350$ ).

Another layer, the frequency of student language by activity structure by condition was also analyzed. Only the highest four activity structures where student language was detected was analyzed. The results indicated that during ASK/ANS activity structures, students in the treatment classrooms responded in English more frequently (85.10%,  $n=239$ ) than in control classrooms (80.40%,  $n=160$ ). This means that ELs in treatment classrooms had more opportunities for “student-talk” and/or “teacher-to-student interactions” than those ELs participating in control classrooms. While the percentages may not appear to be large in nature, when looking at the count between the two groups, there is a difference of 79 occasions where students used the English language to communicate in observed in control classrooms.

When looking at the EV/PER activity structure, there exists a large difference in the use of the English language. In treatment classrooms, participants responded in English more frequently (81.00%,  $n=209$ ) than in control classrooms (62.50%,  $n=35$ ). This activity structure encompasses teachers providing academic feedback and making verbal corrections while students are performing an academic task. It is evident, by the analysis, that ELs in the treatment classrooms were purposefully given more opportunities for engaging in academic tasks while receiving feedback as well as verbal corrections from the teacher.

Additionally, in the OBS/PER activity structure, the use of the English language was observed more times in the treatment classrooms (92.50%) than in the control classrooms

(45.80%). During the observation piece of the activity structure, the teacher is supervising students as they complete academic activities. This also includes informal socializing; this provides for many times in which students can engage in the language with their peers, in written format, or in interactions with the teacher. There was also a difference in control and treatment classrooms during the LEC/LIS in regards to the amount of English used. It was observed that more English was used in control classrooms (11.30%, n=34) as opposed to treatment classrooms (1.00%, n=2) during this activity structure. This is to say that during the time when teachers in control classrooms were lecturing, students were talking. Again, this could mean that the students in control classrooms were not paying attention to the lecture at all.

This question also inquired about the Spanish language used in the classrooms by the students; however, when analyzing the data, there was not an overwhelming difference between classrooms indicating that Spanish was used more in one group than the other. In fact, in these classrooms, while the TBOP did purposefully record the use of Spanish, there were not many instances where Spanish was used; therefore, I did not feel it was necessary to include the use of Spanish by the students as a part of the findings.

### **Limitations**

This present study utilized archived data from one of two treatment groups, CRISELLA, from a larger study, ELLA-V. The main limitation from utilizing this archived data was that it may be possible that these results are not generalizable to all EL populations; however, it should be stated that results could be true of those students who may have similar characteristics of ELs living on the Texas-Mexico border. Still, it should be noted that the statistical power of the study

is enough to provide critical insight into the role of content-area reading and its benefits on student achievement in terms of language development.

### **Conclusions and Recommendations**

While there may be many studies acknowledging the need for an integrated approach of science and literature in the secondary levels, the impact of such instruction at the elementary levels is limited (Cervetti et al., 2012). In fact, science national data is non-existent until students reach the upper elementary or middle school grades. However, Palincsar (2005) noted that when children are given the opportunity to acquire knowledge through content area reading, students further their vocabulary abilities, knowledge of the real-world, and begin to demonstrate a comfort of engaging in such structure of informational texts.

Results of my study demonstrate that ELs who received a literacy-infused, inquiry-based science intervention focused on content area reading instruction were able to make greater gains in language development as noted by their post-test means on two subtests, picture vocabulary and verbal analogies, emphasizing the development of oral language expressive skills. In addition, the study found that there was no statistically significant interaction between gender and the intervention. This is essential because it shows that the intervention did not have a greater effect for either gender. Differences in gender in regards to achievement in STEM have been noted to begin exhibiting in the first grade; hence, this intervention provided for both males and females in order to increase language development and further achievement in STEM disciplines.

Additionally, the study demonstrated that in classrooms in which teachers were intentional in planning activity structures with content-area instruction according to the literacy-

infused, inquiry-based intervention, there was a difference between those control classrooms where the activity structures planned did not include the use of student language. The lack of planning for activities in which students could participate in “student-talk” or “teacher-to-student interactions” limited the opportunities in which the further development of the English language could be fostered.

## REFERENCES

- Amaral, O.M., Garrison, L., & Klentschy, M. (2002). Helping English learners increase achievement through inquiry-based science instruction. *Bilingual Research Journal*, 26(2), 213-239.
- August, D., Artzi, L., Barr, C. (2016). Helping ELLs meet standards in English language arts and science: An intervention focused on academic vocabulary. *Reading & Writing Quarterly* 32, 373-396.
- Barber, A.T., Buehl, M.M., Kidd, J.K., Sturtevant, E.G., Nuland, L.R., & Beck, J. (2015). Reading engagement in social studies: Exploring the role of a social studies literacy intervention on reading comprehension, reading self-efficacy, and engagement in middle school students with different language backgrounds. *Reading Psychology*, 36, 31-85.
- Becks, I., McKeown, M., & Kucan, L. (2002). *Bringing words to life: Robust vocabulary instruction*. New York: Guilford Press.
- Brownsville TX Population. (2018, June 12). Retrieved from <http://worldpopulationview.com>
- Campbell, J. R., Hombo, C. M., & Mazzeo, J. (2000). NAEP 1999 trends in academic progress: Three decades of student performance (NCES 2000-469). Washington, DC: U.S. Department of Education, National Center for Education Statistics.
- Chinn, C. A., Anderson, R. C., & Waggoner, M. A. (2001). Patterns of discourse in two kinds of literature discussion. *Reading Research Quarterly*, 36, 378–411.
- Cronbach, L. J. (1942) An analysis of techniques for diagnostic vocabulary testing. *Journal of Educational Research*, 36, 206-217.
- Cummins, J. (1991). Interdependence of first- and second-language proficiency in bilingual children. In E. Bialystok (Ed.), *Language processing in bilingual children* (pp.70-89).

Cambridge, UK.

- Curran, F.C., & Kellogg, A.T., (2016). Understanding science achievement gaps by race/ethnicity and gender in kindergarten and first grade, *Educational Researcher*, 45(5), 273-282.
- DeBoers, G. (2000). Scientific Literacy: Another look at its historical and contemporary meanings and its relationship to science education reform. *Journal of Research in Science Teaching*, 37(6), 582-601.
- DiRanna, K., & Gomez-Zwiep, S. (2013). High-quality science instruction: Building conceptual understanding and language skills for English learners. [A report from the Region IX Equity Assistance Center at WestEd.] SanFrancisco: WestEd.
- Fisher, D., & Ivey, G. (2005). Literacy and language as learning in content-area classes: A departure from every teacher a teacher of reading. *Action in Teacher Education*, 27(2), 3-11.
- Frumkin, R. (2010). Vocabulary plus: Comprehensive vocabulary instruction for English learners. *The Language and Literacy Spectrum*, 20, 53-68.
- Garza, T., Huerta, M., Spies, T.G., Lara-Alecio, R., Irby, B.J., Tong, F. (2018). Science classroom interactions and academic language use with English learners. *International Journal of Science and Math Education*, 16, 1499-1519.
- Goodson, B. D., Layzer, C. J., & Smith, W. C. (2006). *Observation Measures of Language and Literacy in Early Childhood (OMLIT)*. Cambridge, MA: Abt Associates.
- Grigg, W., Lauko, M., & Brockway, D. (2006). The Nation's Report Card Science 2005: Assessment of student performance in grades 4, 8, and 12 (NCES 2006-466). U.S. Department of Education, National Center for Educational Statistics. Washington, DC:



- U.S. Government Printing Office.
- Hakuta, K., Santos, M., & Fang, Z. (2013). Challenges and opportunities for language learning in the context of the CCSS and the NGSS. *Journal of Adolescent & Adult Literacy*, 56(6), 451-454. doi:10.1002/jaal.164
- Hirsh, E. D. (2006). *The knowledge deficit: Closing the shocking education gap for American children*. New York, NY: Houghton Mifflin.
- Hornberger, N. H. (2005). Nichols to NCLB: Local and global perspectives on U.S. language education policy. *Working Papers in Educational Linguistics*, 20(2), 1-17.
- Huerta, M. & Spies, T. (2016). Science inquiry and writing for ELLs: A gateway for building understanding and academic language. *Science Activities*, 53(1), 24-32. Retrieved from <http://dx.doi.org/10.1080/00368121.2015.1103693>
- Jacoby, J.W. & Lesaux, N.K. (2014). Support for extended discourse in teacher talk with linguistically diverse preschoolers. *Early Education and Development*, 25, 1162-1179.
- Janzen, J. (2008). Teaching English language learners in the content areas. *Review of Educational Research*, 78(4), 1010-1038.
- Kirch, W. (Eds.). (2008). Test of homogeneity, chi-square. *Encyclopedia of Public Health*. Springer, Dordrecht.
- Klein, A. (2015, April 10). No Child Left Behind: An Overview. *Education Week*. Retrieved Month Day, Year from <https://www.edweek.org/ew/section/multimedia/no-child-left-behind-overview-definition-summary.html>
- Kohlhass, K., Lin, H., & Chu, K. (2010). Disaggregated outcomes of gender, ethnicity, and poverty on fifth grade science performance. *Research in Middle Level Education Online*, 33(7), 1-12.

- Lara-Alecio, R., & Parker, R. (1994). A pedagogical model for transitional English bilingual classrooms. *Bilingual Research Journal*, 18(3&4), 119-133.  
doi:10.1080/15235882.1994.10162671
- Liberati A., Altman D. G., Tetzlaff J., Mulrow C., Gøtzsche P. C., et al. (2009). The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: Explanation and elaboration. *The BMJ*, Retrieved from <https://www.bmj.com/content/339/bmj.b2700.full?view=long&pmid=19622552>
- Lemke, J. L. (1990). *Talking science: Language, learning, and values*. Norwood, NJ: Ablex.
- Lems, K., Miller, L. D., & Soro, T. M. (2017). *Building Literacy with English Language Learners, Second Edition: Insights From Linguistics* (Vol. Second edition). New York: The Guilford Press. Retrieved from <http://ezproxy.library.tamu.edu.srv-proxy2.library.tamu.edu/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=nlebk&AN=1535663&site=eds-live>
- Long, Gary (2008, October 20). *BISD revels in honor of winning broad prize*. Retrieved from <https://www.brownsvilleherald.com/>
- Luby, M.F., Griffith, R.R., Silva, C., Weinburgh, M.H. (2016). Assessing ELLs' reading comprehension and science understanding using retellings. *Electronic Journal of Science Education*, 20(3), 150-166.
- Luster, J. (2012). Using state assessments for teaching English language learners. *Research in Higher Education Journal*, 18, 1-10.
- Marzano, R.J., & Pickering, D.J. (2005). *Building academic vocabulary: Teacher's manual*, Association for Supervision and Curriculum Development. Alexandria, VA.
- Migration Policy Institute. (2018). *English language learners: Demographics, outcomes, and*

- state accountability policies* [PDF file]. Retrieved from  
file:///Users/lirios/Downloads/EL-factsheet2018-Texas\_Final.pdf
- Moje, E.B., Ciechanowski, K.M., Kramer, K., Ellis, L., Carrillo, R., Collazo, T. (2004). Workgin toward third space in content area literacy: An examination of everyday funds of knowledge and Discourse. *Reading Research Quarterly*, 39(1), 38-70.
- Morgan, P. L., Farkas, G., Hillemeier, M. M., & Maczuga, S. (2016). Science achievement gaps begin very early, persist, and are largely explained by modifiable factors. *Educational Researcher*, 45(1), 18–35.
- National Center for Education Statistics. (2015). *The Nation's Report Card: Science 2015. National assessment of educational progress at grade 4* (NCES 2015 – 455). National Center for Education Statistics, Institute of Education Sciences, US Department of Education, Washington, DC.
- National Center for Education Statistics. (2017). *Our nation's English learners*. (n.d.). Retrieved from <https://www2.ed.gov/datastory/el-characteristics/index.html#one>
- National Research Council 1996. *National Science Education Standards*. Washington, DC: The National Academies Press. <https://doi.org/10.17226/4962>.
- Palincsar, A. S. (2005). Reading in science: Why, what, and how (Brief). Washington, DC: NSRC. Retrieved from <http://nsrconline.org/pdf/ReadingInScienceEssay.pdf>.
- Partnership, G. S. (2013, August 29). English-Language Learner Definition. Retrieved March 14, 2019, from <https://www.edglossary.org/english-language-learner/>
- Patchen, A.K., Zhang, L., Barnett, M. (2016). Growing plants and scientists: Fostering positive attitudes towards Science among all participants in an afterschool hydroponics program. *Journal of Science and Technology Education*, 26, 279-294, DOI 10.1007/s10956-016-9678-5

- Pew Research Center. (2017). Key findings about U.S. immigrants. Retrieved from <http://www.pewresearch.org/fact-tank/2017/05/03/key-findings-about-u-s-immigrants/>
- Pew Research Center. (2015). Hispanics of Salvadoran origin in the United States. Retrieved from <http://www.pewhispanic.org/2015/09/15/hispanics-of-salvadoran-origin-in-the-united-states-2013/>
- Rodriguez-Valls, F. (2009). Cooperative bi-literacy: Parents, students, and teachers read to transform. *English Teaching: Practice and Critique*, 8(2), 114-136.
- Rosebery, A. S., Warren, B., & Conant, F. R. (1992). Appropriating scientific discourse: Findings from language minority classrooms. *The Journal of the Learning Sciences*, 2(1), 61–94.
- Ruiz-Primo, M. A., Li, M., Ayala, C., & Shavelson, R. J. (2004). Evaluating students' science notebooks as an assessment tool. *International Journal of Science Education*, 26(12), 1477-1506.
- Scantlebury, K., & Baker, D. (2007). Gender issues in science education research: Remembering where the difference lies. In S. K. Abell & N. G. Lederman (Eds.), *Handbook of research on science education* (pp. 257–285). Mahwah, NJ: Lawrence Erlbaum.
- Snow, C. E., Tabors, P. O., & Dickinson, D. K. (2001). Language development in the preschool years. In D. K. Dickinson & P. O. Tabors (Eds.), *Beginning literacy with language: Young children learning at home and school* (pp. 1–25). Baltimore, MD: Brookes.
- Taboada, A. (2009). English-language learners, vocabulary, and reading comprehension: What we know and what we need to know, *Literary Issues During Changing Times: A Call to Action*, 307-322.

- Texas Education Agency. (2018). Bilingual Education Program. Retrieved March 14, 2019 from [https://projects.esc20.net/upload/page/0083/docs/Bilingual\\_Brochure.pdf](https://projects.esc20.net/upload/page/0083/docs/Bilingual_Brochure.pdf)
- Texas Education Agency. (2018). English Learner Reclassification Criteria Chart. Retrieved March 14, 2019 from [http://elltx.org/docs/2018-2019/English\\_Learner\\_Reclassification\\_Criteria\\_Chart\\_2018-2019.pdf](http://elltx.org/docs/2018-2019/English_Learner_Reclassification_Criteria_Chart_2018-2019.pdf)
- Texas Education Agency. (2018). Supporting English learners in Texas. Retrieved March 14, 2019 from [http://www.elltx.org/bilingual\\_esl.html](http://www.elltx.org/bilingual_esl.html)
- Tong, F., Irby, B.J., Lara-Alecio, R., Guerrero, C., Fan, Y., & Huerta, M. (2014). A randomized study of a literacy-integrated science intervention for low-socio-economic status middle school students: Findings from first-year implementation. *International Journal of Science Education*, 36(12), 2083-2109, DOI: 10.1080/09500693.2014.883107
- Tong, F., Irby, B.J., Lara-Alecio, R., Koch, J. (2014). Integrating literacy and science for English language learners: From learning-to-read to reading-to-learn. *The Journal of Educational Research*, 107:410-426.
- Two-way ANCOVA in SPSS Statistics step-by-step procedure including testing of assumptions: Two-way ANCOVA in SPSS Statistics. (n.d.). *Laerd Statistics Web site*. Retrieved September 2, 2019 from <https://statistics.laerd.com/spss-tutorials/two-way-ancova-using-spss-statistics.php#experimental-studies>
- Varela, M., Pappas, C.C., Rifer, A. (2005). Dialogic inquiry in an urban second-grade classroom: How intertextuality shapes and is shaped by social interactions and scientific understandings. In R. Yerrick & W. M. Roth (Eds.), *Establishing scientific classroom discourse communities: Multiple voices of teaching and learning research* (pp. 139–163). Mahwah, NJ: Lawrence Erlbaum Associates.

Wilkinson, A. (1965). *The concept of oracy*, Educational Review, 17(4), 11-15, DOI:  
10.1080/0013191770170401a

Weinburg, M., Silva, C., Smith, K.H., Grouix, J., Nettles, J. (2014). The intersection of inquiry-based science and language: Preparing teachers for ELL classrooms. *Journal of Science and Technology Education*, 25, 519-541, DOI 10.1007/s10972-014-9389-9